POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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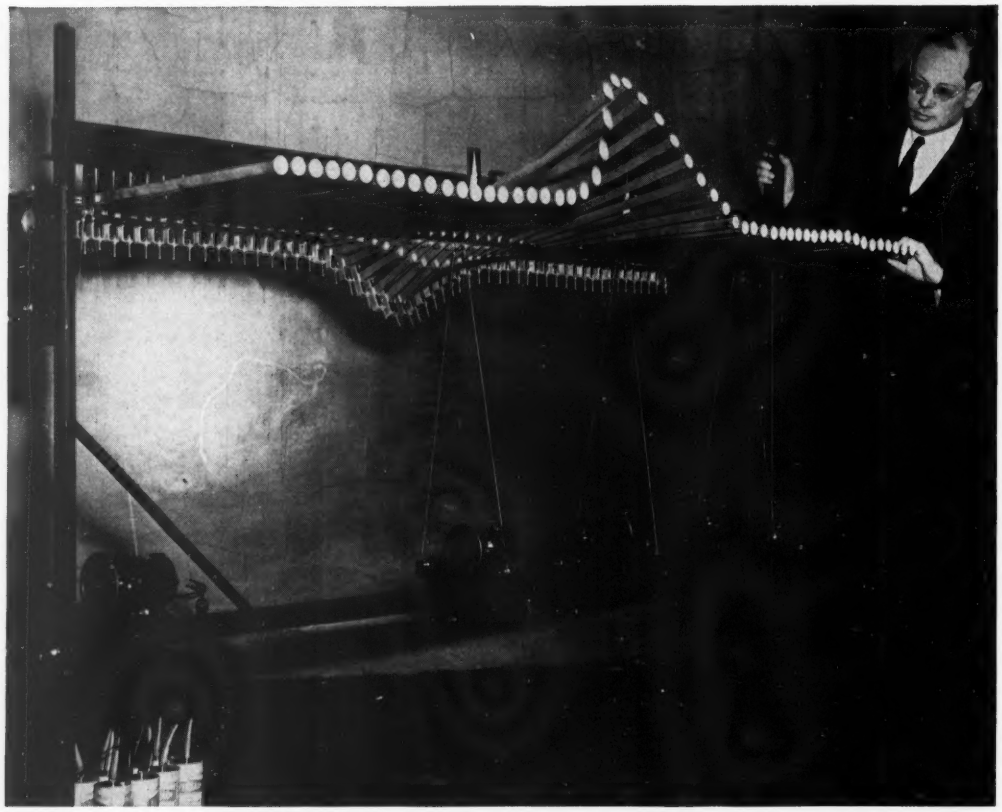

SUGAR COATED TRANSIENTS

ONLY those who have struggled laboriously and often hopelessly with the mathematical intricacies of transient electrical phenomena can really appreciate the beauty of this strange looking device. No, it is not a xylophone. It is an apparatus which, mechanically, simulates the electrical phenomena of traveling waves on power transmission lines. It enables one to visualize complex transient phenomena that, without it, might take weeks and even months of study. As one engineer put it after seeing a demonstration of this device before the Chicago section of the A. I. E. E. recently, "it provides in the space of a single hour, the equivalent of a year's study in college." That was putting it a little strongly perhaps, but the fact remains that it does give one a remarkable insight into the mechanics of traveling electric wanes with practically no effort on the part of the spectator. Invented by C. F. Wagner of the Westinghouse Electric and Manufacturing Co. it is being shown before various engineering audiences throughout the country. As explained in greater detail on page 809 of this issue the device consists of 56 aluminum arms, pivoted on steel bearings and connected to each other by flat steel springs. Any movement of the first arm is transmitted to the adjacent one through the spring and in a disturbance started at one end will travel slowly to the other end in the form of a wave. The mass of the arms is equivalent to inductance in an electric circuit and the elasticity of the springs represents capacity. Since these are the two vital properties which characterize the action of transients on an electrical line, a model such as this, possessing the mechanical equivalent of these properties, will accurately simulate this action of electrical transients in a realistic and objective manner.

WITH THE EDITORS

Those Troublesome Specifications

SPECIFICATIONS for the purchase of equipment fall in the twilight zone between the engineering, the legal and the purchasing departments and, except in large organizations, are apt to prove a trial to everyone concerned, including the manufacturers who are invited to submit proposals. Mark Twain proved to be wrong about the weather but his remarks might well be paraphrased to "Everyone talks about specifications but no one does anything about them." As a result that they are treasured like family heirlooms and handed down from generation to generation until the original purpose is lost sight of and the major portion is meaningless.

Finally POWER PLANT ENGINEERING enlisted the aid of the industry and did something about it. The result of two years' work is printed later in this issue as Part VI, the conclusion of a series of articles on the subject. Combustion control was selected for specific treatment because it is the newest and at the same time most involved of all specifications, because it is concerned with practically every piece of major equipment in the plant and more or less complete combustion control systems are made by somewhat over a dozen manufacturers. Reprints of the entire series will be available shortly after the first of the year at a nominal price to be announced later.

The specifications are adaptable to any type of fuel, auxiliary equipment and arrangement and are arranged so that the major portion can be used without change. While applying specifically to combustion control, the general form and arrangement can be used to advantage for specifications of any kind.

TVA Power

ON AUGUST 31, Knoxville, Tenn., the first large scale demonstration of power distribution at TVA rates, completed one year's service. Serving a territory with a total population of about 160,000 the city purchased 170,220,000-kw-hr., which, with an allowance for loss, represents roughly an average annual consumption of about 1000 kw-hr. per capita or about 5300 per customer.

Under private ownership in 1937, the average domestic consumption was 966 kw-hr. per customer or about 22 per cent above the national average of 732. During the past year the consumption at Knoxville increased steadily and based on August, 1939, is estimated as 1285 kw-hr. on an annual basis. This rapid increase in power consumption has been reflected in increased sale of electric appliances which averaged $65.70 per customer during the past 12 mo.

Purchased at wholesale for about 4.1 mills, the power cost $700,051, the largest single item in the total operating costs of $1,167,934. Based on a total operating revenue of $1,929,482, and no losses, the average retail price was somewhat over 1.13 ct. per kw-hr. As an indication of the domestic price the published report compares the average bill for June, 1938, $3.65 for 85 kw-hr., with the same month for 1939, $2.58 for 104 kw-hr., on the surface a reduction of about 40 per cent per kw-hr. or 22½ per cent more power for about 30 per cent less money.

The income account of the Bureau of Power, Knoxville Electric Power and Water Board shows operating revenue deductions of $141,333 for depreciation and $137,999 for taxes. This latter item amounts to about 7.15 per cent of the gross revenue which is less than half of the national average tax burden of private utilities. The tax allowance, however, is based on only 8 mo. operation as four months taxes were included in the purchase price of the city. On a 12 mo. basis, taxes would have amounted to about 10½ per cent of the operating revenues.

While the report and balance sheet is valuable as an indication of operation of a large city under TVA power rates and will undoubtedly be subject to close study and analysis by utility and other municipal systems alike, there is still left unanswered the more comprehensive and important matter of the TVA operation as a whole—the story behind the 4.1 mills which Knoxville pays for wholesale power.

Operating Problems

TOO MANY plants are designed and built on the drawing board without considering the matter of practical operation or utilizing the assistance which the operating engineer can and should be given an opportunity to render. Design is more or less a temporary matter of a year or two at most while operation extends over a period of from 10 to 30 yr. The designer can build into the plant all that latest equipment and arrangements permit. Whether they are used depends largely on the operators and the facilities provided for the operators to do their job with the least effort.

Such things as valve stems projecting into the aisles, valves, pipes and projecting corners at just the right height to strike a man's head, unlighted corners, inaccessible valves and stairways, inadequate walkways and gratings are details which tell plainly how much experience the designer has had. It is not likely that the operating men will overlook such mistakes and a competent detail man will not make the same error twice.

More fundamental, however, are provisions which must or should be made to meet local conditions and problems. Practically every operating man can remember emergency operating conditions which came about through lack of flexibility in the piping or supply arrangements, sometimes something which could occur at no other plant, sometimes something that might occur anywhere. It is in cases of this kind that the operator can cooperate with the designer to best advantage so that the plant can be laid out to best meet local problems in a way that the operators can then handle with the least difficulty.

DERBY TOPS

Connecticut utility tops a 5000 kw., 175 lb., 500 deg. F. turbine with a 3500 kw., 650 lb., 750 deg. F. machine to increase capacity and meet the needs connected with the sale of high pressure steam. Steam supplied by a 125,000 lb. per hour single boiler with unique superheater characteristics designed to give constant steam temperature at the top turbine exhaust.

By
Charles O. Lenz, Consulting Engineer
and
John B. Saxe, Engineer
Gibbs & Hill, Inc.
New York City

RECENT INSTALLATION of a topping or superposed unit by the Derby Gas & Electric Co. exemplifies the results possible from a relatively small unit of this type with moderate pressure and temperature conditions. For some years the company had been supplementing the output of its generating station, on the east bank of the Housatonic River at Derby, Conn., by purchasing standby service and some firm capacity through an interconnection with the Connecticut Light & Power System. Despite the depression, the growth of the connected load continued, resulting in new peaks in the activity of 1937. A program of electrification of certain copper and brass mills in its territory imposed substantial load on the system and the economic means of providing capacity to satisfy the increased demand thus became an issue.

The original facilities consisted of two 5000-kw. and one 3000-kw. G. E. turbo-generator sets, taking steam at 175 lb., 500 deg. F. and exhausting to 28 in. vacuum. The two 5000 kw. units were equipped with surface condensers and the 3000 kw. set with a barometric condenser. No provision had been made for extraction of steam from the 5000-kw. turbines and investigation revealed that utilizing of extraction, at the only feasible point, would not be economic.

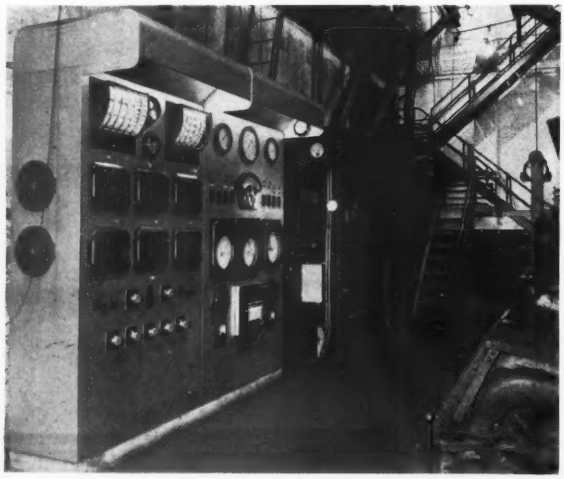

Fig. 1. The boiler room with the new boiler at the far side of the control panel

Steam was supplied by eight longitudinal drum, sectional header boilers, fired by multiple-retort underfeed stokers with gases removed by natural draft. In recent years, the sale of a considerable quantity of steam at boiler pressure to nearby industries had been undertaken and this business expanded rapidly.

The method of increasing station capacity which required the smallest investment and provided high thermal efficiency was to top or superpose the existing machines with non-condensing units. In addition, the topping installation enjoyed a marked advantage with respect to generation of by-product power from the sold steam and required no change in the condensing water source and facilities. Investigation of the existing turbines showed that, aside from the lack of an extraction point, their economy was very close to a modern machine's under similar conditions and that their physical condition indicated continued reliable operation.

Initial steam conditions of 650 lb. pressure and 750 deg. F. were selected as providing maximum thermal efficiency consistent with high availability and operating comfort, especially in view of the high feedwater make-up due to sold steam, size of the unit, and other operating conditions. The size of the unit topping one of the 5000-kw. low pressure machines, supplying the sold steam load, was established at 3500 kw., requiring complementary boiler capacity of 125,000 lb. per hr. Construction of the first unit was authorized in April, 1938.

Steam Generating Unit

It was possible to use a two-drum integral furnace type of boiler within the confines of the existing building with fans and dust collector in the basement, thus avoiding extensive and costly building changes. The

steaming capacity of the B. & W. boiler is 125,000 lb. an hr. at a pressure of 675 lb. and a total temperature of 750 deg. F. at the superheater outlet. Because of the fluctuating characteristic of the sold steam load, the size of the steam drum was increased from the standard 54 to 60 in. diam. drum to provide ample liberating surface. The furnace is completely water cooled, including the sloping floor of the ash hopper at the rear.

Heat release at full rating is 25,700 B.t.u. per cu. ft. per hr. and the furnace is designed for coals with ash fusion temperature as low as 2400 deg. F. and volatiles up to 26 per cent. At full rating, the unit evaporates 13.0 lb. of steam per sq. ft. of boiler heating surface per hr. Heat recovery apparatus con-

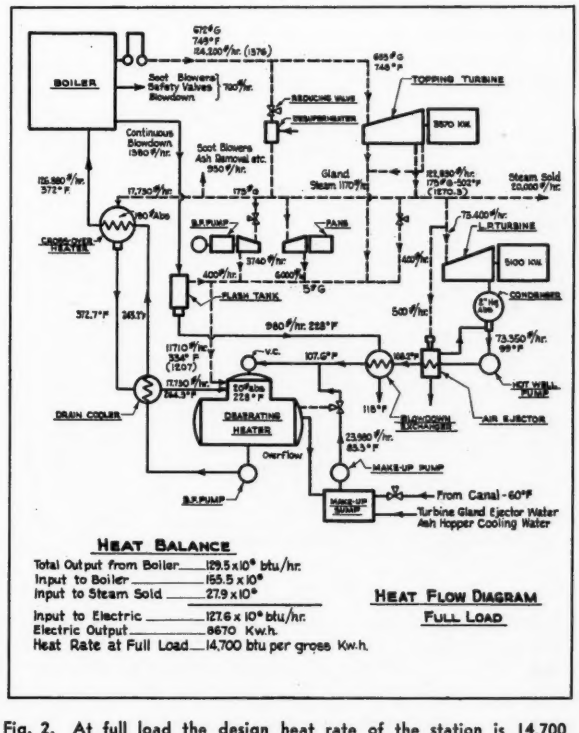

Fig. 2. At full load the design heat rate of the station is 14,700 B.t.u. per kw-hr. generated

sists of a vertical tubular air heater reducing exit gas temperature to 390 deg. F., raising air temperature to 470 deg. F. and resulting in a combined overall efficiency of 85 per cent at full rating.

The superheater is an inverted loop tube, self drainable type with full drooping convection characteristic designed to produce a uniform temperature at the exhaust of the topping turbine under a wide range of loads without control of superheat or desuperheating of the turbine exhaust. The boiler is completely steel encased and insulated with blanket and plastic to give a heat level of 120 deg. F.

Three Diamond retractable soot blowers, using high pressure steam, are installed in the rear wall and roof of the furnace for cleaning the entrance to the first pass. Five other blowers of the usual type clean the superheater and the rest of the boiler. Special blocks facilitate blowing ash from the floor of the furnace into the hopper in the rear. At the top, three sides of the ash hopper consist of firebrick walls supported on steel beams through air cooled castings, the rear being of sloping, water-cooled, block covered construction. The bottom of the hopper is lined with fire and insulating brick and steel encased throughout with a steep slope at the rear on which the dry ash discharges freely by gravity through the intake doors.

An unusual feature is the water jacketing of the entire steel casing to cool the hopper bottom, cooling water being recovered in the make-up sump. Ash is removed by United steam vacuum conveyor, from five intake points and conveyed to a receiver at the top of a 30-t. tile storage tank. Operation of the steam exhauster is automatically intermittent, ash discharging from the receiver to the tank when the vacuum is broken with the steam from the exhauster being silenced and washed before vending. Ash is removed from the storage tank to trucks through a dustless unloader.

Both forced and induced draft fans are of Sirocco multi-blade design with maximum speed of about 900 r.p.m. and are driven by steam turbines through reduction gears. Existing solid wheel turbines which had been in service for many years were reconditioned and used for this service. Forced and induced draft are controlled by varying turbine speed without damper supplement. Gas from the boiler outlet passes downward through the tubular air heater and is then drawn horizontally through the centrifgual type dust collector to the induced draft fan in the basement. A small exhauster fan draws the dust laden gas to a cyclone outside the building where the dust is separated and collected in a storage bin, the clear gas being recirculated to the collector entrance.

The boiler is direct-fired by two B. & W., Type E, pulverizers, each pulverizer serving two combination coal and oil burners, one of which is designed for low load firing. Fuel feed is controlled automatically by a Bailey controller which maintains a relation between pressure drops across the mill and across an orifice in the primary air line by operating a two-speed feeder motor. Hoppers were installed for storing a limited amount of coal to each pulverizer but the original lorries for weighing and distributing coal were retained.

Two, eight stage 3600 r.p.m. I-R centrifugal boiler feed pumps were installed, handling a maximum of 367 g.p.m. at 228 deg. F. against 850 lb. pressure at the discharge. One pump is driven electrically by a 250 hp. induction motor and the other is equipped with dual drive. An interesting feature is the control of the steam turbine of the dual drive which carries as much of the power load as can be generated from the steam make-up required to maintain a constant pressure in the deaerating heater, the balance of the power required being supplied by the motor. A regulator governed by heater pressure controls a steam admission valve to the turbine and is also equipped so as to open the valve wide on electrical power failure, the turbine constant speed governor taking control at slightly higher than motor speed. The pump by-passes are controlled manually and normally left open, being closed only to carry abnormally high ratings.

The Copes feedwater regulator has two controlling elements, water level and steam flow, the influence of each element being adjustable. The feedwater valve is hydraulically controlled by the regulator and has characteristics which handle satisfactorily all excess pressure from the constant speed pumps. The valve is also equipped with an electric drive so that automatic feed can be cut out and feedwater valve remotely controlled from the control board. Emergency feed to the boiler is made through an independent 4-in. line direct from the pump discharge header with handwheel control only.

Combustion is controlled automatically for both coal and oil firing by the L. & N. system, with a master controller handling the furnace draft, air flow, and fuel controllers. Air flow is controlled by varying the speed of both forced and induced draft fans with

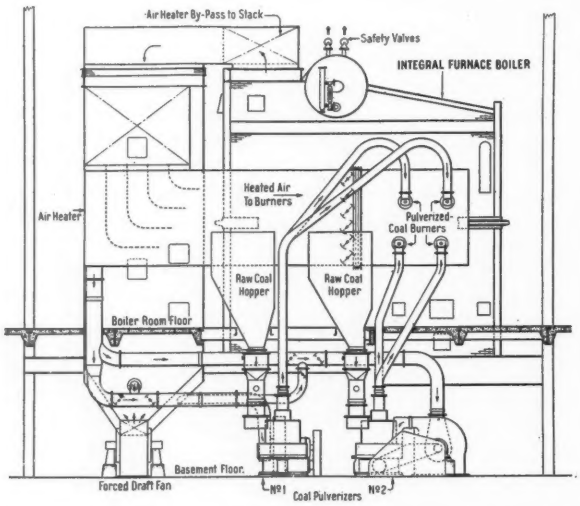

Fig. 3. Front elevation of the boiler showing the arrangement of the pulverizers and forced draft fan

secondary correction of forced draft fan speed for furnace draft. The control provides: full automatic operation for both coal and oil firing; remote control; and a combination with furnace draft controlled automatically, remote control for the remainder. Remote control of a damper by-passing the air heater, dust collector, and induced draft fan to the stack is also provided. The controllers, control valves and switches are mounted on one panel with differential, pressure and draft gages immediately above. The rest of the instruments are mounted on a separate panel immediately adjacent. An annunciator alarm system is also incorporated on the instrument board which warns the operators as to lack of forced or induced draft, high or low water level, low rate of feedwater flow, and high coal-air temperatures from the mills.

Steam is admitted to the turbine generator at 650 lb., 750 deg. F. through eight valves, some of which by-pass the first stages, and passes through 11 stages of impulse blading driving the rotor at 3600 r.p.m. Governing is normally from back pressure but can be from speed if desired. Installation of a desuperheater in the turbine exhaust was omitted as steam temperatures are practically constant under all load conditions. Temperature alarms warn the operators before the unit motors, and, an auxiliary switch operated from the throttle valve opens the generator breaker on overspeed trip. The generator rated at 3500 kw., 0.8 p.f., 7200 v., is separately excited and air cooled. Pressure gages, temperature indicators and flow meter are mounted on a turbine panel board.

The turbine is by-passed by a Republic-Smoot 5-in. reducing valve and steam atomizing desuperheating station designed to pass 150,000 lb. per hr. of steam and automatically maintain pressure slightly under the normal of 175 lb. and temperature at 500 deg. F. The regulators are air operated and arranged for remote manual control from the turbine panel board. The reducing station is used to bring the boiler and topping turbine on the line and also to carry light steam loads. Normally when the turbine is operating, it is tight closed ready to come in on drop in pressure in the 175 lb. main.

Feedwater make-up is in the order of 25 per cent and is taken from the Housatonic River, being relatively soft and free from solids. Water sealing the tur-

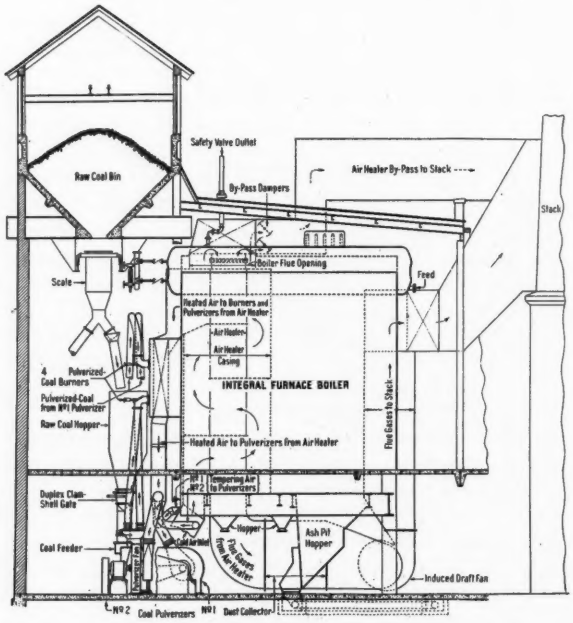

Fig. 4. Side elevation of the boiler with details of the ducts and bypass

bine glands, cooling the ash hopper, and from the canal, flows by gravity into a sump under the basement floor, admission of canal water being float controlled. Vertical deep well type pumps mounted on the basement floor above the sump supply the deaerating heater. Other than a minor external treatment necessary to keep the heaters clean, boiler water conditioning is done internally. Concentrations are controlled by continuous blowdown with heat recovery by flashing into the 5-lb. exhaust header and by transfer in an exchanger to the condensate returns.

Feedwater heating is limited to two stages, the first stage being at 5 lb. ga. in an Elliott open deaerating heater and the second stage at 175 lb. ga. crossover pressure in an Alco closed heater with water going to the

boiler at a temperature of 370 deg. F. The deaerating heater is of Armco iron welded construction, has a capacity of 250,000 lb. per hour with zero oxygen providing for two units and is integrally mounted on a 5000 gal. welded steel storage tank, 4000 gallons being reserved for storage and the balance for normal surges. The closed feedwater heater is vertically mounted and has four passes on the water side. Drains from the closed heater are cooled in a supplementary liquid exchanger transferring heat to the incoming feedwater. A drain controller governs the flow so as to maintain a fixed level below the tubes in the base of the closed heater.

Normally all possible heating steam is depleted for auxiliary power since the heat cycle is automatically balanced by regulating make-up steam through the turbine end of the dual drive boiler feed pump, thus overcoming partially the lack of an extraction point on the low pressure machines and retaining most of the advantages of the steam drive on the essential auxiliaries. When the electric driven pump is operated the balance is held by a reducing valve of special design for normal dead end service. An unusual feature is the emergency supply of feedwater to the old boilers from the high pressure pump discharge header through a water pressure reducing valve of special design.

Full provision was made in all the piping for installation of the second unit. The main steam piping was welded throughout, turbine and boiler lead valves being welded to the main 12 in. header and stress relieved in the shop. The non-return valve was welded to the superheater outlet and this and other field welds were stress relieved in the field. The turbine lead was creased to provide the required flexibility.

Fuel oil burning was originally considered as a standby to the coal firing as space for handling equipment and for storage of fuel was limited. Authorization for construction of such facilities was made in the summer of 1938 when fuel oil went to a discount with respect to coal. The main oil storage tank is of butt welded construction, 54 ft. in diam. by 24 ft. high, with a capacity of 10,000 bbl. and is surrounded by dyke walls. A suction heater and heating coils are provided for warming oil when withdrawing from storage. An auxiliary tank of 15,000 gal. capacity was placed underground beside the main tank for the purpose of receiving oil by gravity from trucks on the driveway as rapidly as they could discharge. An electrically driven Kinney rotary type pump transfers the oil to another underground auxiliary tank of 15,000 gal. capacity on the south side of the building from which the burner pumps take their suction. The transfer pump is piped so that it can also pump to and from the storage tank.

Two Enco pumps, one a duplex steam type and the other an electrically driven screw type, are provided for bringing the oil to a pressure of 250 lb. at the burners. Two tubular heaters bring the oil to a controlled temperature of about 200 deg. F. Interconnecting piping is arranged so that any piece of equipment can be serviced without interruption of oil flow. Steam-mechanical oil atomizers are used with the B. & W. combination burners.

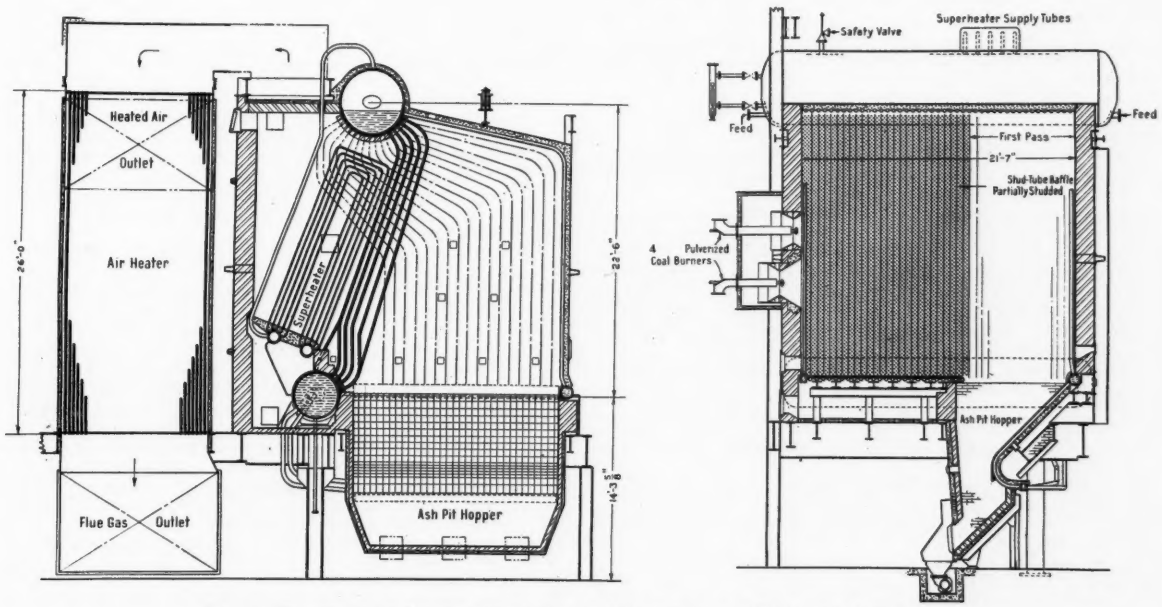

Fig. 5. The new boiler has a capacity of 125,000 lb. per hr. of 675 lb., 750 deg. F. steam

The original auxiliary power supply which was taken from the 2300 v. bus through a 375 kv-a. transformer bank and supplied at 440 v. was inadequate for the added load. Another circuit was taken from the main generator bus at 7200 v. through a new 750 kv-a. bank of single phase transformers. Both the new and original circuits were connected to a new 440 v. distribution board of live-front construction which was separately housed on one side of the heater room. The two main supply leads and the boiler feed pump leads are connected through electrically operated air circuit breakers. The remainder of the circuits were connected through fused switches and magnetic contactors where it was convenient to locate the latter on the board. All

the new motors installed, including the 250-hp. induction motors driving the boiler feed pumps, are started across the line.

Features of the construction were the handling of the 30-t. upper drum of the boiler, placing the 15,000 gal. fuel oil receiving tank underground while heavy trucks were unloading coal on the adjacent concrete driveway and the general execution of the work and crowded quarters without interference to plant operations. The boiler was erected by the contractors with supervision by the manufacturers. Erection of boiler steel was started late in September of 1938 and steam was generated in the new unit with coal firing on March 24, 1939, eleven months after the project was authorized. The turbine was synchronized and put on the line on April 17th; oil firing was started on May 8th. Operating experience with the new equipment has been unusually satisfactory and the actual heat rate of the high pressure unit is somewhat better than original expectations.

Engineering design, construction and supervision of initial operations were carried out by Gibbs & Hill, Inc., in cooperation with officials of the Derby Gas & Electric Co.

EDITOR'S NOTE: Further details of the oil firing system, superheater characteristics and combustion control will be found in the Practical Engineer section.

PRINCIPAL NEW EQUIPMENT DERBY GAS AND ELECTRIC CO. SUPERPOSED UNIT

STEAM GENERATING EQUIPMENT:

Integral furnace pulverized fuel and oil fired boiler with water walls and loop tube superheater, maximum continuous steaming capacity 125,000 lb. per hr., working steam pressure 675 lb., total steam temperature 750 deg. F., maximum drum pressure 725 lb., furnace volume 5900 cu. ft., total steam generating surface 11,480 sq. ft. Air heater, 10,320 sq. ft. vertical tubular welded element.—Babcock & Wilcox Co.

Boiler and furnace setting.—Geo. Allen & Son.

Ash Hopper.—United Conveyor Corp.

BOILER AUXILIARY EQUIPMENT:

Combination coal and oil burners. Steam-mechanical oil atomizers. Coal pulverizers, 2-6270 lb. each per hr., Type E. —Babcock & Wilcox Co.

Pulverizer and feeder drive motors.—General Electric Co.

Forced draft fan, Sirocco, D.I. 2/3 D.W. variable speed, max. 41,100 c.f.m., 100-deg. F., 11.7 in w.g., 955 r.p.m. Induced draft fan, Sirocco, D.I. ½ D.W., variable speed, max. 78,500 c.f.m., 440 deg. F., 10.5 in w.g., 855 r.p.m.—American Blower Corp.

Fan drive reduction gears, Sykes herringbone.—Farrel Birmingham Co.

Soot blowers, 3 retractable, 3 rotating, 2 stationary.—Diamond Power Spec. Corp.

Ducts and breeching.—Connery Constr. Co.

Automatic combustion control.—Leeds & Northrup Co.

Water columns and gage glasses.—Diamond Power Spec. Corp.

Chemical feed pump.—Hills-McCanna Co.

Continuous blowdown system.—Cochrane Corp.

Heat insulation, boiler, air heater and ducts.—Eagle-Picher Lead Co.

Ash handling equipment.—United Conveyor Corp.

FEEDWATER SYSTEM:

Deaerating heater, 250,000 lb. per hr., 1-5 lb. ga., zero oxygen, and 5000 gal. storage tank.—Elliott Co.

Closed heater, 200 lb. pressure, 622 sq. ft. surface, vertical, ¾ in. arsenical copper tubes.—Alco Products Corp.

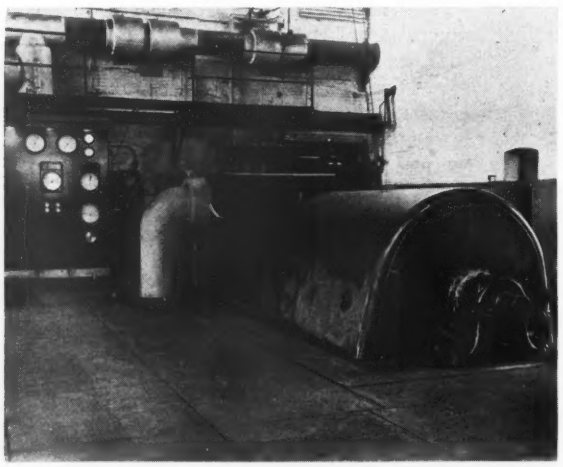

Fig. 6. The 3500 kw. top turbine exhausts at 175 lb. ga. to the old plant system

Heater drain cooler, 200 lb. pressure, 60 sq. ft. surface, horizontal ⅝ in. arsenical copper tubes, 1000 lb. pressure in tubes and heads.—Griscom-Russell Co.

Heater drainage controller.—Stets Co.

Boiler feed pumps, two Cameron No. 3, HMT-8 stage, 3600 r.p.m., 367 g.p.m., 2031 ft. head.—Ingersoll-Rand Co.

Boiler Feed Pump Drives. Two squirrel cage motors, 250 hp., 3600 r.p.m., 440 v.—General Electric Co.; and one 272 hp. steam turbine, 175 lb., 500 deg. F., 5 lb. hp.—Terry Steam Turbine Co.

Feedwater regulator, Copes 2 element control.—Northern Equipment Co.

Vertical make-up pumps, two 7 in. 6-stage deep well, 1750 r.p.m., 7½ hp. G.E. motors.—American Well Works.

Hot well pumps, two No. 3 DHW 2-state, 220 g.p.m., 154 ft. head, 15 hp.—G.E. motors.—Ingersoll-Rand Co.

PIPING SYSTEMS:

High, intermediate and low pressure piping.—M. W. Kellogg Co.

Boiler safety valves.—Consolidated Ashcroft Hancock.

Intermediate pressure relief valves.—Atwood Morrill Co.

Blowndown valves.—Yarnall-Waring Co.

Non-return valve, 8" globe type welded ends and steel stop and check valves.—Edward Valve & Mfg. Co.

Steel gate and globe valves.—Lunkenheimer Co.

Small steel globe valves.—Consolidated Ashcroft Hancock.

Small steel gate valves.—Chapman Valve Mfg. Co.

Iron gate, globe and check valves.—Lunkenheimer Co. and Reading, Pratt & Cady.

Pressure reducing and desuperheating station, one 5 in. reducing valve, steam atomizing desuperheater and controls.—Republic Flow Meters Co.

Feed pump turbine admission valve and regulator and feedwater pressure reducing valve and regulator.—Ruggles Klingemann Mfg. Co.

Heat insulation, piping and auxiliaries.—Johns-Manville.

Pipe hangers.—Grinnell Co.

Traps.—Yarnall Waring Co.

Valve operator, Limitorque.—Philadelphia Gear Works.

METERS AND INSTRUMENTS:

Boiler Meter.—Bailey Meter Co.

Level recorder, feedwater flow and turbine exhaust meters.—Cochrane Corp.

Differential pressure and draft gages.—The Hays Corp.

6-point temperature recorder and indicators.—The Bristol Co.

Industrial indicating thermometers.—Taylor Instrument Cos.

Pressure gages.—Consolidated Ashcroft Hancock.

Fuel oil and water meters.—National Meter Co.

Turbine panel board.—Energy Control Co.

GENERATOR UNIT:

Turbine-generator and air cooler, one 3500 kw., 3600 r.p.m. turbine, throttle conditions—650 lb. 750 deg. F., exhaust 175 lb. ga. driving a 4375 kv-a., 0.8 p.f., 3 ph., 60 cycle, generator.—General Electric Co.

FUEL OIL FACILITIES:

Oil heating and pump set.—The Engineer Co.

Main storage tank, 10,000 bbl. capacity.—Chicago Bridge & Iron Wks.

Auxiliary tanks.—Norwalk Tank Co.

Tank level indicator.—Liquidometer Corp.

Fuel oil transfer pump.—Kinney Mfg. Co.

ELECTRICAL AUXILIARIES:

750 kv-a. transformer bank, three single phase 7200 to 480 v. self-cooled transformers and 440 v. auxiliary distribution board.—General Electric Co.

This study was made with two purposes in mind; both concerned not so much the designer of mechanism as the user, the man who has to live with electrical apparatus. In his contacts with maintenance men, the author has noticed that the adjective "trip free" was enough to place the mechanism so described into a class apart, something complicated and troublesome and not to be lightly meddled with. The first object then was to tear the veil aside and show that trip free mechanisms could be and are simple, and that the principle of operation can be determined by inspection. Experience has also shown that in case of trouble in the field there is a tendency to change the parts to obtain some immediately apparent advantage in operation. The second purpose then is to show that the proportions and configuration of parts were definitely planned to obtain proper force characteristics and to give some information as to the lines along which the designer reasoned, so that no modifications of any of the equipments would be considered unless full weight was given to all necessary requirements.

Trip Free Mechanisms For Operation of Circuit Breakers

By CARL THUMIM

Switchgear Division, Philadelphia Works
General Electric Co.

THE OPERATING MECHANISM provides the means for closing the circuit breaker and for opening it, or allowing it to open under the proper conditions. These two functions are circumscribed by a number of requirements. The power consumption and time for closing are generally limited. The current for opening must be as small as practicable to obtain the generally required high speed of tripping. Both closing and opening must be highly reliable and must function under wide limits of applied voltage, the tolerances for closing generally being minus 28 per cent and plus 4 per cent of the normal rated voltage, while those for opening are minus 44 per cent and plus 12 per cent of the normal.

Three main parts compose the operating mechanism; the power unit which furnishes the closing power; the trip latch which permits the mechanism to open; and the linkage which forms the connections between the power unit, the latch and the circuit breaker. The power unit may be one of several types: manual, electrical such as solenoid or motor, fluid such as pneumatic or hydraulic and stored energy such as springs. The latch may be of several types such as hook, toggle, or dead center roller and may be actuated in a number of ways such as manually, electrically by solenoid or motor, by spring and by magnetic releases.

The linkage, which is the subject of this article, provides the foundation upon which the varying characteristics of the breaker, the power unit, and the latch are built to form a unified mechanism having the required qualities. This linkage can take various forms and work through different media, the basic ones of which will be described and analyzed below.

Non-Trip Free Mechanism

In the simplest form of operating mechanism, the force is transmitted from the power unit directly to the circuit breaker until the latter is fully closed. At this point the linkage is latched in and holds the breaker in the closed position when the closing force is removed. To open the breaker, this latch is tripped and the reaction of the breaker forces it open. A simple mechanism of this type is shown in Fig. 1. At 1a, breaker and mechanism are in the open position. When closing member A is actuated, it moves lever C counterclockwise around stationary axis J until the closed position of the breaker connected to D is reached. At this point, prop F (Fig. 1b) is forced under roller E by spring L until stop K touches the roller. Now the closing force may be de-energized and the breaker is kept from opening by the support of F. To allow the breaker to open, trip member H is energized and when supporting surface of F is moved beyond the center of roller E, the back pressure of the breaker contacts, springs and weight cause it to open.

With this type of mechanism, as long as the closing member A is actuated, the breaker will remain closed. If it is desirable to open the breaker at the end of the closing stroke due to some emergency such as a short circuit on the line, and the trip member is energized, the breaker will nevertheless remain closed until the closing force is removed. This con-

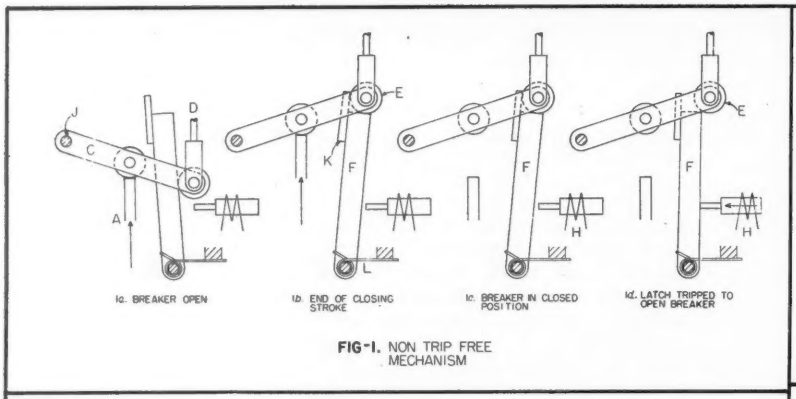

FIG-1. NON TRIP FREE MECHANISM

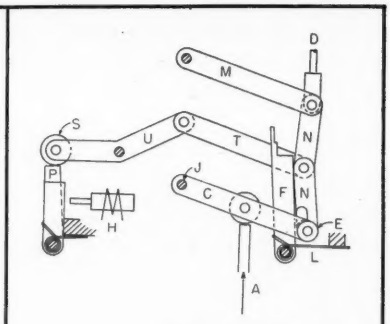

FIG-5. CLASS B TRIP FREE LINKAGE

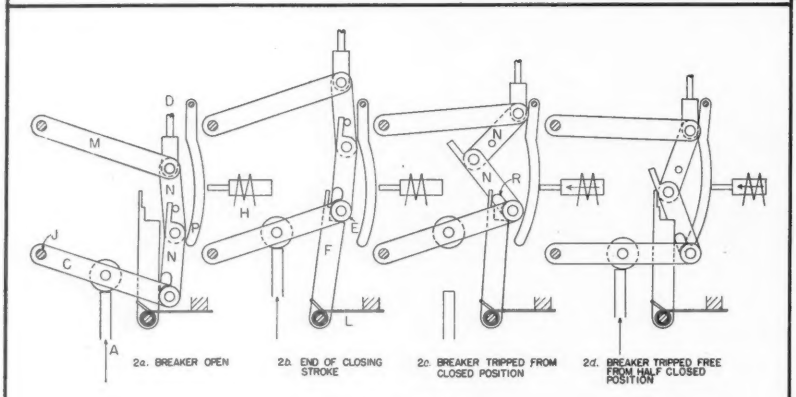
2a. BREAKER OPEN
2b. END OF CLOSING STROKE
2c. BREAKER TRIPPED FROM CLOSED POSITION
2d. BREAKER TRIPPED FREE FROM HALF CLOSED POSITION

FIG-2. CLASS C TRIP FREE LINKAGE

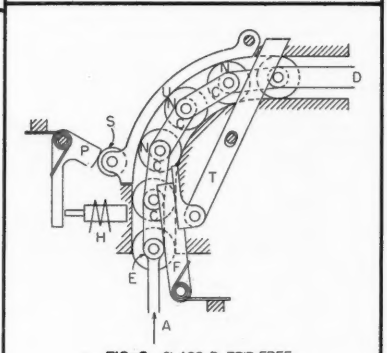

FIG-6. CLASS B TRIP FREE LINKAGE EMPLOYING A COMPRESSION CHAIN

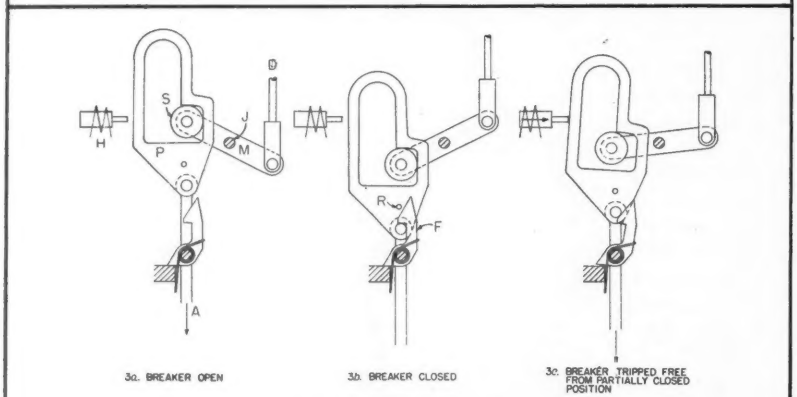

FIG-3. CLASS C TRIP FREE LINKAGE

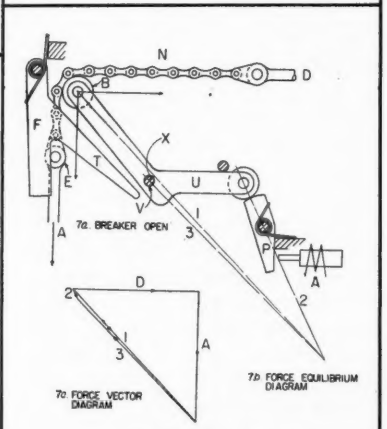

FIG-7. CLASS B TRIP FREE LINKAGE EMPLOYING A TENSION CHAIN

dition is undesirable due to the fact that the fault is not cleared immediately and may do damage both at the point where it occurs and to the transmission and generating equipment.

General Trip Free Mechanisms

To eliminate this objection, most modern mechanisms are designed to trip-free of the closing force. The best forms of mechanism are not only mechanically trip-free from the instant the breaker contacts touch, but trip-free during the entire closing stroke. While the former type provides protection against line faults from the instant that contacts touch until the breaker is fully closed, the latter, in addition, is more universal in its application, as it is not affected by the point in the stroke at which contacts touch, a point which varies greatly depending on the length of breaker stroke. Moreover, the trip may be locked or interlocked in the open position, thereby preventing the closing of the breaker in any manner or to any extent.

Depending on the mechanical principles used, the trip free linkage may be classified into two general types. First, there is the collapsible link type in which a collapsible link is interposed between the part actuated by the closing member and the part

attached to the breaker. This collapsible link forms the trip latch. During the closing operation, it may act as a solid link, but if the tripping means is energized at any portion of the stroke, the link collapses, breaks the thrust transmitting structure, and permits the breaker to open while the closing force is still being applied. As one of the characteristics of this type is that the whole trip latch moves during closing, the tripping means must be so formed that it will actuate the trip latch at every point of its stroke. This sometimes prevents difficulties and is the reason why such mechanisms were often trip free only during

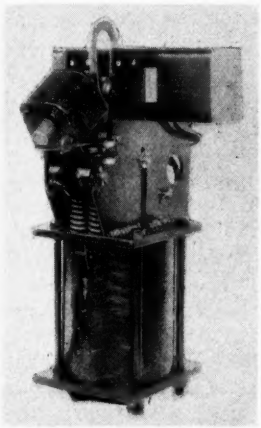

Fig. 4 Solenoid operating mechanism using class 3 linkage of Fig. 3

the last portion of the closing stroke. With proper design this condition can be overcome.

The second general form of trip free linkage may be called the reaction type. It may be best described by considering a single lever to one point of which is attached the breaker, to the second the closing force, the third being a pivot held temporarily fixed by the trip latch. During normal closing this latch is in the thrust supporting state and acts as a fulcrum. When the tripping means is energized, the latch collapses and removes its support from the lever, and the breaker opens, since the resistance it affords to the motion of the lever is greater than that obtained from the collapsed latch structure. Since with this type the latch is stationary, it may be caused to collapse at any point of the closing stroke with equal facility.

The physical embodiment of these two types takes various forms, some of which are described below.

Collapsible Link Types

This type may again be sub-divided into two designs, differing in the method of locking of the collapsible link. In the first, which we shall call Class C,

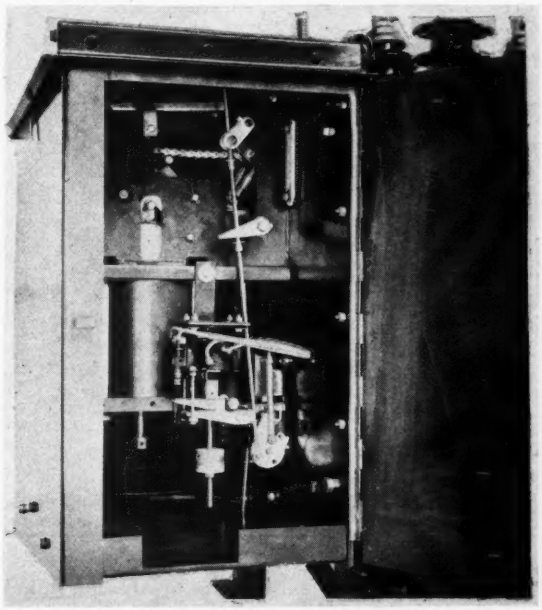

Fig. 8. Outdoor oil circuit breaker with class B solenoid operating mechanism

the link and its latch are a unit and travel together. In the second, to be designated as Class B, the collapsible link travels, but is held from collapsing by the use of some member intermediate between itself and a stationary latch. The latter is more intricate but has the advantage that contact between the collapsible link and the tripping means can never be lost.

Figure 2 shows schematically the action of the Class C mechanism. At "2a" the mechanism is shown with breaker open and latch reset, ready for closing. When closing force is applied in direction of arrow A, it rotates beam C, counterclockwise around fixed point J. The force is transmitted to breaker oper-

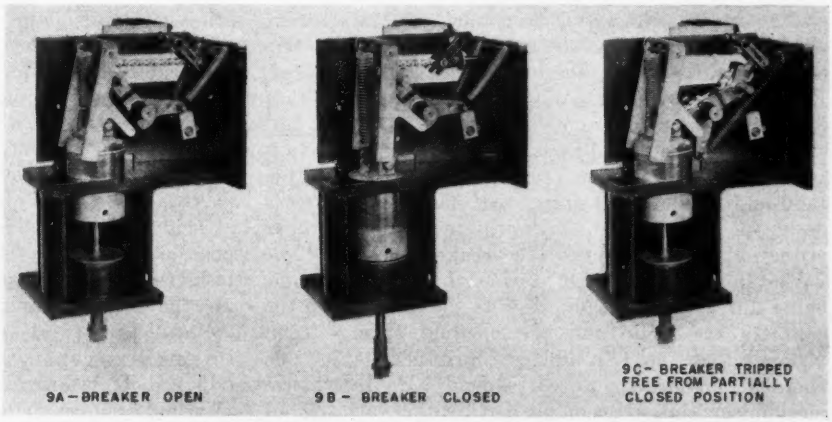

Fig. 9. Solenoid operating mechanism using type B trip free linkage of Fig. 7

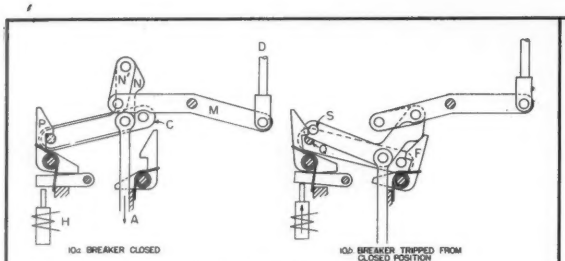

FIG-10. CLASS B TRIP FREE LINKAGE

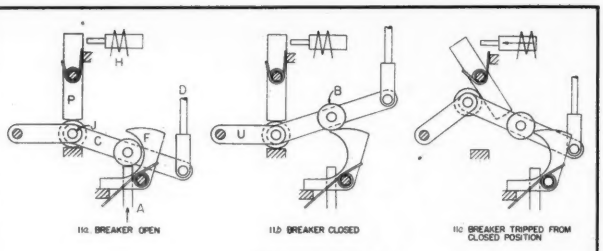

FIG-11. CLASS A TRIP FREE LINKAGE

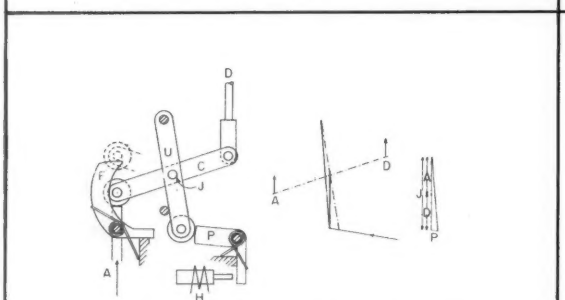

FIG-12. CLASS A TRIP FREE LINKAGE WITH TRIP FORCE REDUCTION

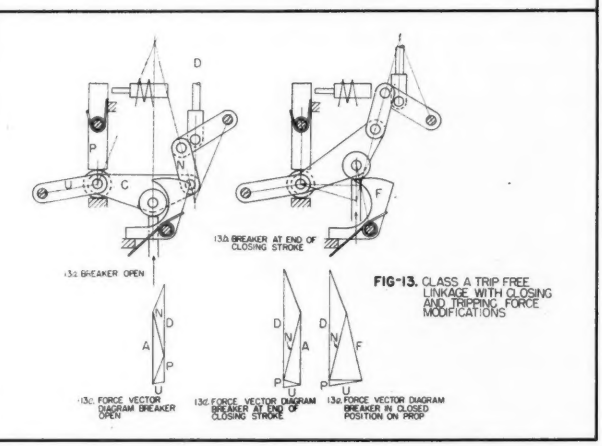
13a BREAKER OPEN
13b BREAKER AT END OF CLOSING STROKE
13c FORCE VECTOR DIAGRAM BREAKER OPEN
13d FORCE VECTOR DIAGRAM BREAKER AT END OF CLOSING STROKE
13e FORCE VECTOR DIAGRAM BREAKER IN CLOSED POSITION ON PROP

FIG-13. CLASS A TRIP FREE LINKAGE WITH CLOSING AND TRIPPING FORCE MODIFICATIONS

ating rod D, which is held in place by spacing link M, through the medium of over-center toggle N. Adjacent to the middle joint of the toggle is trip lever P, so shaped that it is within a small predetermined distance from the joint during the entire closing stroke. If at any time trip coil H is energized, P will be driven against the toggle which will be pushed over center and will collapse due to the force exerted on it by the breaker. When the closing stroke is completed, prop F gets under roller E, (Fig. 2b) and holds the breaker and the mechanism linkage in the closed position. After this point is reached, the closing force may reset, leaving the structure supported in the closed position by prop F. If the trip is energized when the breaker is in the closed position, the trip coil causes collapse of toggle N (Fig. 2c), thus permitting the opening of breaker connected to D and the motion of one of the toggle links, causes its extended portion R to strike an extension on prop F and to remove the latter from under roller E, permitting the lever C and the toggle to reset. If the trip coil is energized, when the breaker is partially closed, Fig. 2d, the tripping action is similar, except that it is unnecessary to remove the prop.

Depending on conditions, the tripping force available may be anywhere from one tenth to one ten thousandths of the closing force. This necessitates a design of trip linkage which will provide the proper reduction. In some cases, the breaker resisting force varies in such a manner during the closing stroke, being low at the start and high at the finish when the contacts are made and the opening springs compressed, that the trip linkage must change its mechanical advantage to correspond. In the above mechanism, this is accomplished by the variation of the leverage of P as the toggle center moves during the closing stroke.

Another embodiment of this type is shown in Fig. 3 where closing force A closes breaker attached at D by causing the counterclockwise rotation of lever M pivoted at J through the medium of latch link P, and roller S. At any portion of the closing stroke, Fig. 3a, trip coil plunger H can drive P to the right and disengaged it from the roller S, thus releasing the breaker. In the closed position, Fig. 3b, the mechanism is held by the hook F when the closing force is de-energized. The breaker may be tripped from the closed position, and P released, and reset by means of springs not shown, when pin R strikes the plow on the hook F as P is driven to the right. In every other portion of the closing stroke, the mechanism is tripped, Fig. 3c, in the same way except that it is unnecessary to remove the hook F. Figure 4 illustrates the use of this linkage in a solenoid operating mechanism for oil circuit breakers.

In contrast to the foregoing mechanism, when the collapsible member includes the latch which is opened by an external tripping means, the Class B mechanism described below has a traveling collapsible link joined to a stationary latch. In Fig. 5, parts A, C, E, F, J, L, M, D, function exactly the same as the similar parts in Fig. 2. Collapsible toggle N, however, instead of being locked over center, is held in an undercenter position by link T, the other end of which is pinned to lever U held in place by roller S and latch P. During the entire closing stroke, the toggle N tends to collapse to the left and to put a counterclockwise turning moment on U resisted by latch P. If the trip coil H is energized, P is rotated counterclockwise and removes the resistance to the movement of U,

thus allowing N to collapse and open the breaker.

A notable variant of the Class B linkage is the one employing a chain as the thrust transmitting member. In Fig. 6 is a British scheme in which chain, having links C and roller N, acts as a compression member between the applied force A and the breaker resisting force connected at D. The chain is restrained by circular channel one side of which is fixed and the other movable. In this case member U is pivoted on a fixed pin at one end and held in place at the other by latch prop P bearing against roller S. When the chain is in compression, rollers N bear hard against member U. Whenever prop P is moved, as by trip coil H, U is released and the chain collapses allowing the breaker to open. In the closed position the chain is locked in place by prop F which is removed from in front of E by the link T when the breaker opens. This permits the collapsible linkage to reset.

While in the above example the full forces of A and D are exerted against U, with therefore a heavy load on the latch, and considerable friction loss during the closing, Fig. 7a illustrates a mechanism which reduced losses and simplified manufacture. N is a standard roller chain which acts as a tension member between the applied force A and the breaker force D and runs over roller B which for economy's sake may be a standard stock sprocket. Roller B is supported by lever U pivoted on fixed pin V and kept from rotation by prop latch P, Pin V is so disposed that the resultant force 1 (equilibrium diagram, without friction—Fig. 7b) of A and D has a moment arm X tending to turn U in a clockwise direction. Following the diagram out further and obtaining the magnitude of the forces from Fig. 7c, it is seen that force 2 on the prop is much smaller than A, thus showing that the trip force has been reduced. For tripping or tripping free, coil H removes prop P, and allows lever U to rotate clockwise, putting slack into the chain and permitting breaker to open. Prop F acts against roller E and holds breaker and mechanism in closed position. Should the linkage then be tripped, an excresence on U strikes the extension T on prop F and forces the release of E. A spring not shown then lifts the chain and all parts attached at E and permits the linkage to reset. Fig. 8 illustrates the use of this linkage Solenoid Operating Mechanism for the outdoor Oil Circuit Breakers. A cut-away view of this mechanism in several positions is shown in Fig. 9.

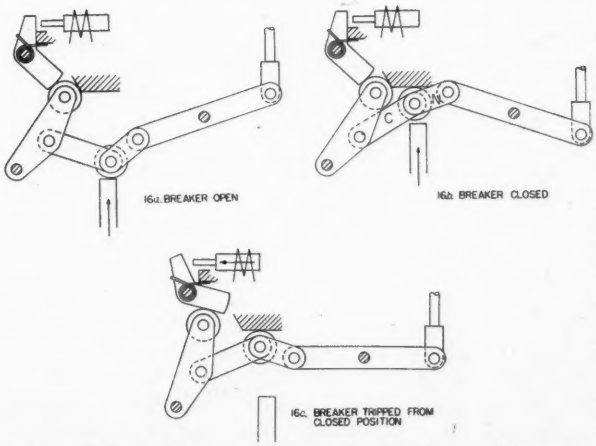

Fig. 14. Class A linkage with tripping and closing force modification

Another linkage used in the United States is shown in Fig. 10. It has the features of the Class B design with a disadvantage in the fact that the latch is not completely isolated from the moving parts. In 10a the linkage is shown in the open position. A is the applied force, D the breaker connection, C the lever to which force A is applied. C is pivoted on stationary pin Q which during closing is exactly in line with pin S which has its bearing in one of the toggle links N. Therefore during closing the pins S and Q being in line, rotation around Q will give rise to no relative motion between C and N. S is held in place by trip latch P. During the closing operation the resistance of breaker at D is exerted through lever M and toggle link N′ to give rise to a clockwise torque on N, which is resisted by latch P. When H is energized anytime during the closing stroke, N would be released and D allowed to open even though A completes the full stroke. Fig. 10b shows the tripping of the breaker from the fully closed position and demonstrates the manner in which the closing hook F is removed by the collapse of toggle N—N′. A spring not shown lifts C and all its attached parts and permits the linkage to reset.

Reaction Type Linkage

This form of linkage has been previously described in principle and will be referred to as the Class A. The basic form is shown in Fig. 11. Closing force A causes rotation of lever C around pivot J temporarily fixed by latch prop P and closes breaker attached to D. The open position is shown at 8a, and the closed position at 11b. When trip coil H is energized, the resistance to the movement of J is removed and if this happens during closing, the breaker will begin to open at once. If the trip is energized with the breaker in the closed position, the force at D will move J up and open the breaker with an instantaneous pivoting action around roller B. In the meantime, the action of spacing link U is to move the lever C bodily to the left and roller B off the prop F as in Fig. 11c. The linkage is then free to reset. If the linkage of Fig. 11 and Fig. 1 are compared, it is seen that the non-trip free linkage can be converted to a Class A trip free linkage by the addition of a prop and one link.

A successful example of the Class A linkage which incorporates a reduction of the tripping force without additional parts is shown in Fig. 12. All parts have the same functions as the similarly numbered parts in Fig. 11. By referring to the equilibrium diagram in Fig. 12b and the force diagram Fig. 12c, the force against the trip latch P is much smaller than the breaker force D. Thus by the proper location and proportions, the force at P can be reduced to a minimum, limited only by friction forces at various pins, which, if not accountetd for, may overcome the tendency to trip.

While the mechanism of Fig. 11 neither reduces the tripping force nor modifies the closing force according to the loads at various points of the stroke, and the mechanism of Fig. 12 reduces the tripping force but leaves the closing force ratios unmodified, Fig. 13 illustrates a modification of the Fig. 11 mechanism in which both purposes are accomplished. The lever C is so proportioned that during closing, the moment arm of the breaker at D, acting through link N, is constantly diminished, with a consequent rise in the closing force. This is shown by force analyses c, d and e which correspond to mechanism positions a and b. At d the force D is much greater than that at c, although the closing force A remains the same. Likewise the tripping forces P are reduced as the breaker is closed, the intention being to maintain a constant tripping force, although the breaker force rises. The analysis Fig. 13e gives the magnitudes of the forces when the closing force is removed and the structure is supported by prop F. It may be seen that with D the same in both Fig. 13d and 13e, P is very nearly the same whether the closing force is at the end of its stroke or when the mechanism remains in a closed position.

All the mechanisms described heretofore show the use of a prop member F to maintain the breaker in the closed position. Where the breaker forces at the end of the closing stroke are large compared to the available closing force, the method using an overcenter toggle may be employed, as shown in Fig. 14. At 16a the mechanism is shown in the open position, latch locked, and ready to close. At 16b, it is locked in the closed position with links C and N over center against the stationary stop. At 16c, the mechanism has been tripped and the breaker is half open. The linkage will reset due to its own weight. It is evident that some savings in money and complication have been effected by the omission of the prop. Moreover, tripping and closing forces have been modified in accordance with the breaker load, without losing simplicity.

In comparing the three types of trip free linkage described above, the latch problem, the behavior under shock, the complication of the linkage and the efficiency in closing will be considered.

The Latch and Shock Problems

In both the Class A and the Class B linkages the latch is stationary. This immediately permits the use of latches more sensitive than moving latches as used in the Class C linkage since they are further removed from the seat of vibration. Where extreme sensitivity is not required, a stationary latch is proof against any shock encountered in operation, especially on fast closing breakers. In every case known to the writer where the Class C linkage was employed in rapidly moving mechanisms, some extraneous means had to be employed to keep the latch from collapsing. This consisted of special adjustment of the latch, unnecessary to the ordinary operation of the trip but required to obtain shock-proofness, or of additional parts to act as secondary locks on the latch. This of course meant additional expense, complication and a decrease in reliability. Moreover, the stationary latch permits more flexibility in the use of parts which would be too heavy to be employed as moving parts.

On the basis of complication, Fig. 12, 7 and 3 representing Classes A, B, and C respectively are taken as the simplest examples of the three types. Fig. 12 has one major moving part. Fig. 7 has the chain and roller as the two main moving parts, while Fig. 3 has the lower and the latch as the important moving parts. Inherently the Class A linkage can arrange some of its closing parts to require a reduced and varied trip force as exemplified by Fig. 10. In the other two types the reduction must start at the point of application of the full breaker load, which precludes of employing some of the linkage preceding that point for trip force reduction. Also, while in the Class A linkage, resetting of the links after tripping may take place without disturbing the prop which holds the breaker in the closed position, in the other two types some means must be provided to remove the props mechanically. These points show that from the viewpoint of complication of mechanism all is in favor of the Class A linkage.

The efficiency of any linkage depends on the number of friction producing parts between the point of input and the point of output. It is obvious that due to the presence of the latch parts in the direct path between these two points in the Class B and C schemes, and the possibility of having no immediate parts between these two points in the Class A scheme, there are fewer friction points in the last, therefore giving better closing efficiency.

Numerical Evaluation

If ordinate values are assigned to the various characteristics, with the greater number of points for the better efficiency, the comparison would be as follows:

	Class A	Class B	Class C
Latch	2	2	1
Shock	2	2	1
Simplicity	3	1	2
Closing Efficiency	3	1	2
Composite Rating	10	6	6

This tabulation does not attempt to weigh the comparative importance of the various factors. In smaller mechanisms, where all forces are comparatively small, shock forces may be of a magnitude which would make the use of a Class C mechanism perfectly satisfactory, especially where gains are made in some other direction such as the economy of application. For similar reasons, it follows that modifications of trip and closing forces are not so necessary, a fact which would permit the use of either Class C or Class B mechanisms. In larger apparatus, however, shock proofness is of major importance, in which case Class B would gain over Class C, although it would lose a little due to greater complication and lower efficiency. The Class C mechanism would then rate as the lowest, the Class B middle and the Class A by far the best of trip free linkages.

Air Heater and Economizer Selection

By ADOLF JOHNSON

THEORETICAL AND PRACTICAL FACTORS which determine the selection of economizers and air heaters have been discussed in two previous articles* from the physical standpoint with the economics touched upon very sketchily. This final phase of the problem will deal with the balancing of heat recovery or fuel savings against the cost of the heat recovery apparatus itself. In other words, what maximum return can a prospective buyer expect with the minimum investment?

The gross income earned by the air heater or economizer is, of course, the actual heat recovered in terms of fuel saving. From the gross income must be subtracted the operating expenses which are chiefly cost of fan power, maintenance and depreciation. The result is the net savings realized. As a rule the net yearly savings should be sufficient to pay for the heat recovery apparatus in a period of about 3 yr., in order to realize a substantial return on the investment.

In the previous discussions of this series, the examples given were based, for simplicity's sake, on a certain definite heat recovery, that is, a given entering flue gas temperature and an assumed exit gas temperature from the heat recovery unit. No mention was made as to how to arrive at the maximum temperature drop (heat recovery) for maximum economic return.

Since the decrease in availability is logarithmic or exponential in character whereas the heat recovery is a function of the gas temperature difference to the power of unity, it can be realized that a limit is reached beyond which the thermal characteristics of the air heater or economizer decreases the net return. To more clearly illustrate the rapid increase in surface (and cost) for each additional increase in heat recovery, we shall set up economizer heating surfaces required for five values of gas temperature drop or heat absorption. The data in Table I will be assumed in determining the economizer sizes:

Table I. Data assumed for the examples

Maximum boiler capacity—lb. of steam per hr.	80,000
W_s—Average plant load, lb. of steam per hr.	40,000
W_g—Gas leaving boiler at ave. load, lbs. per hr.	50,000
T_1—Temp. of gas leaving boiler at ave. load, deg. F.	640
t_1—Temp. of water entering econ., deg. F.	210
c_g—Ave. specific heat of gas in econ., B.t.u. per deg. F.	0.26
T_2—Gas temp. leaving econ. at ave. load, deg. F.	
Econ. No. 1	440
Econ. No. 2	400
Econ. No. 3	360
Econ. No. 4	320
Econ. No. 5	280
Heat transfer rate from gas to water at maximum load, B.t.u. per deg. F. per sq. ft. per hr.	12.0

*See POWER PLANT ENGINEERING, page 301 May 1939 and page 475 July 1939.

It is intended that the examples may serve as a guide or method by which anyone, so desiring, may determine an economical size of heat trap to use for any specific requirement. For this reason the heat transfer rate is given at the maximum load only but a method of determining the heat transfer rate at the average load is presented since it is recognized that the ratio of average load to maximum load varies considerably for each plant. It has been previously stated that the heat transfer rate is approximately proportional to the two-thirds power of the capacity. At the average load of 40,000 lb. of steam per hr., the heat transfer rate would be,

$$(40{,}000 \div 80{,}000)^{\frac{2}{3}} \times 12 = 7.6$$

Any value to the two-thirds power is easily calculated on the slide rule since it merely means the cube root of a quantity squared.

From this data it is possible to determine the log mean temperature difference and calculate the required heating surfaces of each of the five economizers. In Table II is tabulated the calculated heating surfaces and temperature drops through each of these units.

Table II. Heat drops and sizes as calculated for the five economizers assumed

	T_1-T_2 deg. F.	Heating Surface, Sq. Ft.
No. 1	200	1165
No. 2	240	1570
No. 3	280	2030
No. 4	320	2750
No. 5	360	3790

From the above tabulation it is obvious that the heating surface is increasing at a greater rate than the absorption (T_1 — T_2). For instance, economizer No. 5 absorbs 80 per cent more heat than economizer No. 1, but requires 225 per cent more surface to do it. Putting it in another way, the 40 deg. F. increase in absorption between economizer Nos. 4 and 5 requires 1040 sq. ft. of additional surface, whereas for the same 40 deg. F. increase from economizer Nos. 1 to 2 requires only 405 sq. ft. additional surface.

The Financial End

But which economizer saves the most money? Obviously No. 5 saves more coal since it recovers more heat than No. 1, so the gross income of No. 5 is greater than No. 1. If the economizer cost nothing, the problem would be ended because No. 5 would be the obvious choice. Unfortunately, it is a well established fact that you can't get something for nothing. That economizer (or air heater) is going to cost money and require an initial outlay of cold cash. Then it is going to demand more dollars to feed those draft fans, clean those tubes, and replace those replacements.

Replacements, did you say? What can wear out in an economizer and air heater? Why, it's just a lot of tubes or plates with gases and water at comparatively low temperatures flowing around in them. Why, you say, there isn't a moving part in the whole thing except the fans. There may not be any moving part in the ordinary sense of the word, but more happens in heat traps than meets the eye. Differential expansion

Table III. Cost data used in economizer studies

I. Initial Costs
1. Economizers (plain tubes), per sq. ft. of h.s., $2.50.
2. Air heaters.
   Tubular and plate types, per sq. ft. of h.s., $0.65.
   Regenerative type, per sq. ft. of h.s., $1.00.
3. Induced draft fans (including motor), per 100,000 lb. of gas, $2000.
4. Forced draft fans (including motor), per 100,000 lb. of gas, $1000.
5. Flues and Ducts.
   15 per cent of cost of air heater.
   10 per cent of cost of economizer.
   20 per cent of cost of economizer plus air heater.

II. Operating and Maintenance Costs.
1. Electric power for fans, ct. per kw-hr., 0.5.
2. Power to fans.
   Induced draft, kw. per 100,000 lb. of gas per in. of draft loss, 12.
   Forced draft, kw. per 100,000 lb. of air per in. of air resistance, 6.
3. Maintenance.
   For either economizer or air heater 5 per cent of initial cost, per year.
   For combination air heater and economizer, 8 per cent.
4. Interest—6 per cent of initial cost per year.
5. Depreciation—Assume life of economizer—10 years.

of metals, corrosion of the oxygen and sulfurous variety, scale formation in economizer tubes, etc. All these little mishaps come under the category of maintenance and represent a real cost on the balance sheet. Buying a heat trap is an investment in every sense of the word, an investment with profits and losses. Choose an economizer or air heater without a consideration of the profits and losses involved and you are very likely to wind up with additional plant expenditure and no returns, in other words, a white elephant.

Referring back to the economizers we have selected, if we evaluate the fuel savings of each economizer in terms of dollars and cents, and from this savings deduct the losses, we will arrive at the net profit or earnings of each economizer. A comparison of the net earnings of each economizer will then clearly point out the amount of surface that can be installed, or the maximum gas temperature drop that will show the greatest net profit.

For this purpose some approximate cost data will be assumed. The data is fairly representative and can be used for preliminary analysis. However, for more accurate final determinations, price information should be obtained from the manufacturers. Table III gives the cost data used in this analysis.

As a sample calculation we will determine the net yearly profit of economizer No. 1 based on: the cost data in Table III; on 13,000 B.t.u. per lb., $4.00 per t. coal; and an average of 5000 hr. per yr. operation at 40,000 lb. of steam per hr.

From this, Table IV, we see that for an expenditure of $1035 per yr., a savings of $2000 per yr. is effected in the fuel bill and the net savings realized is $965 per year. The per cent return on the investment is, therefore:

$$(965 \div 4201) \times 100 = 23\%$$

Following the same procedure, the net savings have been calculated for the next 3 economizers, the results of which are listed in Table V. This data illustrates clearly that an economizer designed for a gas temperature drop of about 280 deg. F. will result in the maximum net savings per year.

A critical inspection of this table will bring out several interesting points. For instance, an economizer designed for a 320 deg. F. gas drop will result in practically the same net savings as one designed for 280 deg. F. differential, but the initial cost of the unit is $8560 whereas economizer No. 3, designed for less absorption, costs only $6580 initially. This is also reflected in the percent return on the yearly cost which in the case of No. 4 is 14.6 per cent and No. 3 is 19.4 per cent.

Economizer No. 4 would show a nice efficiency on the heat balance charts, but on the cost accounts it shows only that an additional $2000 of initial cost was spent to get the same savings that would result with a smaller initial expenditure. In other words, it is better to let the additional 40 deg. F. difference between economizer Nos. 4 and 3 go up the stack than it is to spend the money to put it back in the heat cycle.

As shown on the table, Economizer No. 3 is the most economical but it requires an initial cost of $6580. Suppose your appropriation is only $4200, what can be done about it? The answer is, go out and buy every square foot you can with it, which in this particular analysis would be economizer No. 1. Even though you wouldn't have the most economical unit, the percent return on the investment is higher than with the most economical unit. The table shows that Economizer No. 1 will give a yearly return of 23.0 per cent on the investment whereas Economizer No. 3 shows only a 19.4 per cent return.

Air Heaters

Table V also lists a similar analysis of four air heaters designed for the same gas temperature differentials as the economizer, so that a comparison between the two is easily made. It is apparent that there is little to choose between the air heater and economizer as far as net savings is concerned. However, the initial

Table IV. Calculation of the yearly profit on Economizer No. 1

FUEL SAVING OR GROSS INCOME

Tons coal saved per year due to economizer heat absorption
$(50{,}000 \times 0.26 \times [640\text{-}440] \times 5000) \div 2000 \times 13{,}000 = 500$ t.
Gross income $500 \times \$4.00 = \$2000$ per year.

INITIAL COSTS

Economizer, 1165 sq. ft. at $2.50 per sq. ft. delivered and erected	
1165×2.50	= $2910
Induced draft fan and motor—50,000 lb. of gas per hr.	
$50{,}000 \div 100{,}000 \times \$2000$	= 1000
Flues, 10 per cent of economizer cost	
0.10×2910	= 291
Total initial cost	$4201

COST PER YEAR

	Per yr.
Fan power consumption, based on 1 in. draft loss at the average load of 40,000 lb. of steam per hr.	
$(50{,}000 \div 100{,}000 \times 12) \times 1 \times \$0.005 \times 5000$	= $ 150
Maintenance, 5 per cent of initial cost	
0.05×4201	= 210
Interest on initial investment at 6 per cent	
0.06×4201	= 255
Depreciation based on 10 year life of unit	
$4201 \div 10$	= 420
Total cost per year for unit	$1035

NET PROFIT PER YEAR

Fuel savings per year less cost per year
$2000 — $1035 = $965 per year.

Table V. Return on the investment as calculated for four sizes of air heaters and economizers

Absorption $T_1 - T_2$ Deg. F.	Temp. Entering T_1 Deg. F.	Temp. Leaving T_2 Deg. F.	Heating Surface Sq. Ft.	Initial Cost $	Gross Saving Per Year $	Cost Per Year $	Net Saving Per Year $	Percent Return on Yearly Cost
Economizer								
200	210	275	1165	4200	2000	1035	965	23.0
240	210	288	1570	5320	2400	1266	1134	21.3
280	210	301	2030	6580	2800	1525	1275	19.4
320	210	314	2750	8560	3200	1950	1250	14.6
Air Heater								
200	80	350	3170	3870	2000	1023	977	25.2
240	80	404	4550	4890	2400	1255	1145	23.5
280	80	458	6380	6260	2800	1523	1277	20.4
320	80	510	9250	8420	3200	1980	1220	14.5

cost of the air heater is somewhat less, which possibly would be the deciding factor in determining whether to install an air heater or economizer. On the other hand, if the air temperatures leaving the air heater are beyond the limit specified for the existing combustion equipment, the choice would definitely be an economizer.

To determine whether an economizer and air heater would increase the net savings per year, the procedure would be to choose the economizer resulting in the maximum saving per year or one a bit smaller, say economizer No. 2, then set up an air heater starting with a 100 deg. F. gas drop and determine the net saving resulting from the economizer and air heater. If the net saving is appreciable, and the initial cost within the budget appropriation, then determine the savings which would result for two or three more air heaters in increments of about 20 degrees additional gas drop. Tabulate this data and select the most economical air heater to add to the economizer. For the example cited in this article, a tabulation based on a combination of air heater and economizer will show no increase in the net saving and considerable increase in initial cost, so the conclusion is that it would be impractical to install both types of heat trap.

In many instances the factors influencing the selecting of a heat trap are such that a unit having as low as 250 or 200 degrees exit gas temperature may be the most economical. If this is the case, then the selection of the most economical unit is governed chiefly by the possibility of rapid deterioration due to corrosion. The causes of corrosion and methods of reducing its action will be dealt with presently. Generally speaking, when the exit gas temperature is in the 300 deg. F. range, it is advisable to follow the manufacturer's recommendation as to the exit gas temperature limit beyond which active corrosion may occur. Air heaters have been known to fail in a few months time because the possibility of corrosion was not considered. Where high sulphur and high moisture content fuels are used, it is particularly important to take into account excessive maintenance due to corrosion.

In an analysis of this nature it must be stressed that so many variables and cost factors are involved, that it is essential to have reliable test data and cost data to arrive at a satisfactory answer to the problem. The more accurate the data, the more reliable the results will be. If the data is not accurate, and it is inconvenient to obtain more reliable information, then the best procedure is to choose an economizer or air heater for a lower absorption than the tabulation indicates, rather than a higher absorption. An analysis of this type will at least indicate whether it pays to invest in a heat trap and if so, approximately how much can be invested without wasting the money.

Reliable test data naturally depends on the accuracy and completeness of your plant records. As far as reliable prices are concerned, it is only necessary to get complete price information on one economizer and one air heater and use the methods outlined in this article to set up the several sizes required for a tabulation. There may be some question about basing economizer and air heater prices on a unit price per square foot regardless of size. It is true that small heat traps have a higher unit cost than larger ones. However, in a cost analysis of this type, there are certain compensating factors which tend to correct this discrepancy.

One factor is draft loss. That is, for a given gas weight and constant heat transfer rate the draft loss will increase in direct proportion to the increase in heating surface. To keep the draft loss within a reasonable amount, the heat transfer rate must be decreased for

(Continued on page 812)

Combustion Control Specifications

By RICHARD H. MORRIS
Engineering Editor

Part VI. The general arrangement of these standard specifications is outlined in the index, Table III, and their use, for a typical plant, is illustrated by example in the following pages. They are divided into five general sections for simplicity and flexibility and to separate insofar as possible, the specifications proper, which deal with necessary data, from the standard or contract portions. They are printed in three kinds of type: regular Roman type for general parts which can be used with little change for any plant; bold face type for parts and details which must be changed for each plant; and italics for complete sections which are applicable only to one particular arrangement, fuel, drive or auxiliary. Alternate sections to substitute for the italic sections for other plant conditions are grouped and classified by fuel, fuel firing and auxiliary drives at the end of the complete specification.

The wide column of each page follows common specification practice with the data incorporated in sentence form. Directly opposite in the narrow column the data and information incorporated in each paragraph is indicated in outline form and explained by notes. As written, the specifications call for a control completely centralized on a panel. Sections and paragraphs marked at the beginning with a double asterisk as ** should be omitted in specifications for a simple positioned control involving primarily a steam pressure controller and a furnace pressure regulator for a small boiler. Requirements for controls falling between these two extremes can be met by using or omitting sections marked ** as needed. When the double asterisks come within a section, the reference applies to the balance of that particular paragraph.

Complete detailed specifications can be written only after a plant is completed. Actually control specifications may be issued long before this, often before some of the major auxiliaries are purchased, so that it is necessary to make assumptions to get a uniform base price and provide for changes which may be necessary to conform to actual requirements.

All names and addresses are intended to be fictitious. While equipment for the assumed plant is all in common use, the selection was made primarily to include a variety and illustrate specific points so that it should not be interpreted as recommendation of either equipment or arrangment.

Table III. General Arrangement and Index of Specifications. This is made complete in order to show the detailed arrangement of the specifications but may be shortened to a more convenient length for actual use by omitting sub-section headings.

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Specifications Covering Automatic Combustion Control for The Blank Mfg. Co. Power House No. 2

Specification No. 1001A

SECTION 1. SCOPE, TIME AND PAYMENT.

CHECK LIST AND NOTES
SECTION 1A
Name of company.
Address of company.
Name of plant.
Address of plant.
What is wanted? Partial or complete control—other information needed to indicate the general requirements.

1A. GENERAL REQUIREMENTS. These specifications cover a **complete** automatic combustion control for the **Blank Mfg. Co. Power House No. 2 at 2717 E. Adams St., Chicago, Ill.** They and the complementary drawings are intended as a complete, but general, description of the work to be done and the results to be accomplished and will automatically become part of the contract when the proposal is properly signed by both parties. Each bidder is free to select and arrange the proposed equipment to best advantage, but neither this nor the general character of the specifications shall be interpreted as removing the responsibility of supplying: all equipment, parts and instruments definitely specified, whether or not they constitute part of the control proper; and, unless specifically excepted in other paragraphs, all equipment and parts needed to accomplish the operations called for by these specifications.

SECTION 1B
Terms used to avoid repetition of long company names.
Responsibility of engineer or party authorized to make and approve changes.

1B. TERMS USED. When used in these specifications the term Purchaser refers to the **Blank Mfg. Co.**; Contractor to the manufacturer submitting a proposal; Engineer, **to the consulting engineer, the Sphinx Engineering Co., 1710 E. Huron St., Chicago, Ill.** The Engineer shall have the power to make and approve changes in the specifications, negotiate and co-operate with the manufacturers and accept the control as satisfactory after installation and test.

SECTION 1C
Date proposals are due.
Number of copies desired.
Specific name and address with instructions for mailing or delivery.

1C. DATE DUE. Proposals **in triplicate (3 copies)**, based on the control f.o.b. factory for installation by the Purchaser and with a supervisor's services quoted at a per diem rate, will be received up to and including **Feb. 15, 1940.** All proposals should be addressed, or delivered, to the **Engineering Department at the** general office of the **Blank Mfg. Co., 213 E. Monroe St., Chicago, Ill.** No proposal will be considered unless each copy conforms to the specifications as outlined in the section "Proposal Requirements."

SECTION 1D
When will the equipment be paid for? The terms given are more or less standard for control equipment purchased for the power plant field. Qualifying clauses provide for payment in case of undue delay or postponed construction without releasing the Contractor from responsibility for the performance of the control when it is eventually installed.

1D. PAYMENT. Payment will be made as follows: 85 per cent of the contract price upon shipment of the complete control, or, if materials are ready and shipment is delayed at the request of the Purchaser, on the shipping date in the contract; the balance of 15 per cent will be paid upon acceptance of the control indicating that the specifications and guarantees have been fulfilled. Living and traveling expenses plus services of the Contractor's representative on a per diem basis will be paid monthly and within 30 da. of the date of the Contractor's invoice covering the previous months' services. In case installation or acceptance is delayed due to any cause not directly attributable to the Contractor or control equipment supplied by him, the balance due on the contract price will be paid not later than 90 da. after the first contract payment of 85 per cent. Under these conditions complete payment shall not be interpreted as implying acceptance of the control nor the release of the Contractor from the responsibility of complying with the guarantees after the installation is completed.

SECTION 1E
Requirements depend on law and precedent.

1E. PERFORMANCE BOND. (This is customary only in the case of public or semi-public bodies. The form, amount and conditions are usually fixed by law and vary so greatly that no effort has been made to prepare a standard form.)

SECTION 2. CONTROL, GUARANTEE AND PROPOSAL REQUIREMENTS.

SECTION 2A
What type of control is wanted and what are the general limitations on design? The purpose of this section as written is to differentiate between two classes of combustion control: (1) the simple positioned type; and (2) a more elaborate type where increased flexibility is desired. "Positioned" and "Metered" are not in general adequate terms to specify controls of the second classification for two reasons: first, while reasonably descriptive when used in connection with a single regulator there is no agreement as to the meaning when applied to a combination of several regulators working together; second, metering a specific quantity is often impossible even in the largest and most modern plants, so positioning must be used with any control. In a given case, this paragraph can be made more specific.

SECTIONS 2B, 2C, 2D
Requirements in this section are general and fundamental, with few exceptions covering features which would be included as standard equipment on any modern combustion control purchased without specifications. As such they are obvious and might well be omitted if it were not for the necessity of differentiating between different classes of controls so as to insure comparable bids. In these Sections 2B, 2C and 2D are complementary to Section 2A. Included complete they cover all the fundamentals of contemporary practice for systems completely centralized on a control panel. Omitting sections marked ** automatically brings the specifications within the limitations of the simplest kind of control without a panel.

2A. **TYPE OF CONTROL. Insofar as practical, the control should be of the metered type with the metered indication taken directly from the quantity controlled, or, from some significant relationship in the steam making or combustion process of each individual boiler. This shall not be interpreted as excluding position type controllers where metering a specific quantity is: impossible; impractical; not necessary with the control proposed; or inadvisable because the Contractor feels that the specifications can be complied with to better advantage by a calibrated positioning device. A master or steam pressure controller may be used to actuate two or more regulators in parallel through a master loading system but with this exception, no regulator shall be responsible for more than one control function. Each regulator shall have a convenient means of changing the relationship with respect to other regulators, adjustments for sensitivity or time of response and other manual or automatic adjustments and features needed to comply with later sections of these specifications.

2B. AUTOMATIC CONTROL. a. GENERAL. The automatic combustion control shall be designed primarily to operate completely one, all, or any combination of boilers in accordance with the steam load and without assistance of the operator **beyond the specific exceptions made later for manual changes in connection with certain auxiliaries.** All parts of the control shall be properly coordinated so as to accomplish the following automatically and simultaneously with no tendency to hunt:

b. STEAM PRESSURE. Control the rate of combustion, or furnace heat release, in accordance with the total steam load so as to maintain the desired steam

**Sections and sentences so marked should be omitted in specifications for a simple position control involving primarily a steam pressure controller and furnace pressure regulator for a small plant. In specifications for other position controls, either with or without a panel, omit Section 1C but include later sections so marked as needed to give the arrangement desired.

pressure at the control point for all loads within the limit set by the load range specified for each boiler and the number of boilers in operation. The steam pressure regulator shall have a convenient means of changing the set pressure, over a limited range above and below the normal value and while the boilers are in operation.

c. FURNACE PRESSURE. Control the pressure in each furnace at the desired value and below atmospheric pressure, and prevent a positive pressure under normal operating conditions. This regulator shall have: a convenient means of changing the set furnace pressure over a limited pressure range while the boiler is in operation; and, an accessible hand set, remote positioning, or, cut-out device, to lock the regulator in position and render it inoperative while blowing tubes.

d. COMBUSTION. Control the fuel-air ratio and combustion conditions in each furnace within the specified load range so as to give smokeless and stable operation at all times and the highest overall boiler efficiency consistent with the boilers and auxiliaries used and with the method of operation. Means shall be provided in connection with the fuel-air ratio control for each boiler, so that the set CO_2 or excess air can be changed as desired within the practical limits set by the equipment.

e. DIVISION OF LOAD. Divide the total steam load between boilers as specified later and within the practical limits set by the boilers and auxiliaries involved and the method of operation.

2C. **OTHER METHODS OF OPERATION. a. GENERAL. The control shall be arranged so that the operator can quickly and conveniently change any, all, or a given combination of boilers from automatic control as outlined above to any one of the control methods outlined below. Except for direct operation, the mechanism for making these changes **shall be incorporated on the control panel** and shall include instruments or indicators as needed to assist the operator in making a change in either direction without disturbance to operation or to the auxiliaries involved. The arrangements must be such that the method of operation of one boiler does not interfere with, and places no restrictions or limitations on, the methods of operation of any other boiler, except as operation may be limited by boiler capacity and the steam load at the time.

b. **SEMI-AUTOMATIC CONTROL. Any boiler, while on semi-automatic control, shall operate at constant rating independent of the steam pressure, but, with automatic control of combustion conditions and furnace pressure similar to full automatic operation, and, without placing any restrictions on provisions made for changing or controlling the fuel-air ratio on that boiler. Means shall also be provided so that the operator can change the rating on that boiler from a single control point **on the panel.**

c. **REMOTE OPERATION. While any boiler is on remote operation, the operator shall be able to operate or move **from the panel front** any single regulator on that boiler, (except the steam pressure regulator) so as to operate the boiler manually at any load. **To facilitate starting up, regulators which have metered connections, or are subject to other than the master loading force, shall have a means of positive remote positioning so that the damper or mechanism involved will stay in position after being set by the operator.**

d. DIRECT OPERATION. With the exception of the steam pressure regulator, each regulator or power operating member shall be arranged so that the operator can, easily and quickly, move the damper or mechanism involved, direct and without using the regulator operating power medium. The Contractor shall provide the necessary lever, handwheel, or, rack and pinion mechanism so that each damper or machine can be moved easily by an operator of average strength. This shall be in addition to any provision made at the regulator or power operating members for manual operation using the regular power operating medium and shall include all special parts but not standard intervening linkage as covered in greater detail later under Miscellaneous Equipment.

2D. **CONTROL BOARD. The control shall include panels or cabinets as necessary to centralize the control functions, mount instruments and other equipment as specified, as well as control parts, instruments and regulators which the Contractor may elect to install there. The arrangement of instruments and controls on the front of the panels shall be subject to approval by the Engineer. This arrangement should be made primarily for the convenience of the operator and to avoid confusion during regular operation or emergencies. Instruments and controls for each boiler shall be grouped and definitely segregated. The panels shall be: made of steel plate sufficiently thick or properly braced to support the necessary equipment: of sufficient size to accommodate the equipment and permit working on, or the removal of, any part; and completely finished in the shop with the necessary cutouts and drillings. Exterior surfaces shall be finished with two coats of **black** lacquer applied over two coats of filler rubbed smooth; the interior with two coats of a paint suitable for this service.

2E. GUARANTEE REQUIREMENTS. a. MATERIALS AND DESIGN. Acceptance of the contract implies that the Contractor assumes full responsibility for the satisfactory performance of the control as a whole and control equipment supplied by him when used under the operating conditions and requirements outlined by these specifications. Acceptance of the control by the Engineer after installation, implies that these requirements have been satisfied and the Contractor freed

In between these two extremes is a broad group of controls which cannot be classified and between which differentiation is difficult. A centralized control, deprived of the panel and with the regulators all located at the machines they move, obviously retains all its operating features except remote control from a central point. A normally decentralized system, supplied with a panel and remote control of regulators would become a centralized system although the cost of adding complete remote control might throw the price out of line. In some cases a compromise, with a smaller, less complete panel is adequate for plant conditions.

The more a control system is designed to do, the more it costs and the plant designer must determine through previous consulation with control manufacturers the approximate cost of certain features and decide how far added control should go in order to justify the expenditure in that particular plant. In this intermediate group of controls it is important that the specifications be written with a lower but with no upper limit. This leaves the way open to get more than expected at a competitive price due to the difference between special and standard equipment. All controls are not well adapted to change and after a definite arrangement is decided upon, it may be found that special features required on a normally cheaper control in order to comply with the specifications, makes it more expensive than standard equipment of another control which is normally more expensive. If not used, the additional features are of no value in themselves but there is always the possibility that they may be used to accomplish at little or no extra cost some detail originally omitted from cost considerations.

Section 2B covers the principal functions of automatic combustion control no matter how simple, while Section 2C covers features which are found only in the more complete systems where increased flexibility is desirable because of operating conditions or the layout of the plant. Neither semi-automatic or remote control necessitate a central panel although such an arrangement is more common. Provision for direct operation should always be provided so that the boiler can be operated without control of any kind in an emergency.

Section 2D on control panels covers only the most general features which should be expected regardless of the extent or arrangement. More specific requirements for a given case should be made in Section 4K. Panels involve a considerable portion of the control cost and are often omitted in smaller plants especially those using few instruments. In the larger plants or where operation is watched more closely, adequate instruments for firing guides and records are provided. Here a panel or panels is a convenience for it groups all essential equipment at one spot accessible to the operator.

In practice the instrument panel and control panel are adjacent and in some cases combined, the exact arrangement depending largely on the control selected. When only two or three boilers are involved, a single panel may be used although some operators and designers prefer to have the controls and instruments split up between a master panel and individual boiler panels, each of the latter being located at a point close to its respective boiler. Recent practice of using a few large boilers rather than a number of small ones rather favors locating all panels at a central point, even though the controls and instruments may be definitely separated between master and individual boiler panels. In many cases a single panel is used with the instruments and controls segregated on different sections of the same panel.

from further responsibility except in connection with defects in the design, workmanship or material of individual pieces of equipment. The Contractor shall agree to replace or repair, f. o. b. factory within a period of one year from date of shipment, any part which, in normal and regular use, fails and upon examination proves to be defective in design, material or workmanship.

b. PERFORMANCE. 1. GENERAL. The Contractor shall guarantee the performance of the control. Where practical, performance will be measured with the regular operating instruments but where the accuracy or adequacy of these instruments make this impractical, or in case of controversy, tests as necessary will be made as provided later. Before these tests are made the Purchaser will calibrate the operating instruments and put the settings and brick work in first class condition, with openings sealed and air leakage maintained at a reasonable figure. The control will be expected to operate satisfactorily under abnormal operating conditions but performance guarantees shall be applicable only to: (1) automatic control under normal operation; (2) for the conditions and over the load range specified; (3) with changes in load not exceeding 15 per cent per minute of the boiler capacity at the beginning of the load change; (4) with fuel of commercially uniform fineness and/or quality; (5) and provided the auxiliaries have the capacities and characteristics specified and the flexibility to follow the control impulses or changes. Under these conditions the control shall be guaranteed to accomplish the following, simultaneously and within the tolerances specified which are to be considered as the maximum allowable:

2. Steam Pressure. Maintain the steam pressure in the header within plus or minus ** 2 per cent **(use 5 per cent for a simple position type control involving only a steam pressure controller and furnace pressure regulator on small boilers)** of the desired value for which set at the time.

3. Furnace Pressure. Maintain the furnace pressure for each boiler within plus or minus 0.05 in. w.g. of the desired value for which set at the time, or, as determined by burner or natural furnace pulsations beyond the influence of the control.

4. **Combustion. Maintain, over extended periods without manual adjustment, combustion conditions for each boiler averaged over a 10 min. period, within plus or minus one per cent for CO_2, or, plus or minus 10 per cent for excess air, of the value for which the control is set at the time; provided, that set value is possible with the equipment involved and can be obtained by manual operation.

5. Division of Load. Divide the total steam load between boilers so that the output of each boiler is within plus or minus 5 per cent of the proportional share or fixed value for which set at the time.

c. FAILURE TO MEET GUARANTEES. If the control does not meet the performance and other requirements of these specifications it shall be optional with the Purchaser to accept the equipment or reject it in whole or in part. The Contractor shall be notified of the decision in writing within two weeks of the completion of the acceptance tests. If it is not accepted, the Contractor shall proceed, at his own expense, to make equipment changes or furnish parts as necessary to bring it up to specification requirements. If the Contractor fails to do this within a period of 6 mo. of the first notification, he shall agree to the return of the equipment in whole or in part to the factory and to the refund of the purchase price less an amount agreed upon at the time for parts which the Purchaser may elect to keep. Labor and material charges in connection with the changes, repairs or rearrangement of other than control equipment will be paid for by the Purchaser. Should investigation prove the fault to lie, wholly or partially, outside the control due to failure of other equipment to meet its guaranteed performance, the expenses in connection with the control changes will be assumed by the Purchaser or equitably divided among the parties involved. This shall not, however, relieve the Contractor of the responsibility of familiarizing himself with, and providing for, the normal characteristics of equipment to be controlled over the entire automatic operating range and not covered by specific guarantee points.

2F. PROPOSAL REQUIREMENTS. a. General. To be considered, each copy of the proposal must be identified on the title or cover page as, **"Specifications for Automatic Combustion Control, Blank Mfg. Co., Power House No. 2, Specification No. 1001A"** plus the contractor's name, and have included the following:

b. Summary. Immediately following the title page, a summary of the price, dimensions, weights, guarantees and time requirements as covered by **Table IV.** Extra copies of this form are provided in the specifications for this purpose. This summary should be supplemented by other sheets as needed to give additions to, or subtractions from, the main proposal price for alternate proposals, as well as, explain alternate proposals and departures from these specifications.

c. Description of Control. A description of individual parts and the control as a whole with adequate explanation and illustrations or drawings necessary to make the principle of operation clear.

d. **Panel. Preliminary sketch or illustration of the panel indicating the general arrangement.

e. Bill of Materials. A complete bill of material of all parts and equipment supplied by Contractor including the torque or thrust rating of each power operating unit or cylinder.

SECTION 2E

Beyond the standard requirements of good design and materials expected of any piece of equipment, the question of guarantee of automatic combustion control is a difficult one to handle. The control is expected to coordinate the operation of several diversified elements, none of which are made by the control manufacturer. While he can guarantee the accuracy and performance of each individual instrument or regulator which he supplies, the overall performance of the control is determined by the performance of equipment for which he is not responsible.

In the past many unreasonable, impossible and meaningless guarantees have been requested and the requirements outlined in Section 2Eb set forth in an effort to standardize requests on a basis which is a real measure of performance. The tolerances given are those which any good control should be able to maintain without difficulty in an average well designed and modern plant.

Assuming that all equipment performs as, and has the characteristics, expected, the critical condition is of course the rate of change of load. The rate given, 15 per cent per minute, is fast for the average central station and in many cases the tolerances specified can be materially reduced, if for instance the change does not exceed 5 per cent per minute.

In many industrial plants, however, the load may change much more rapidly than 15 per cent per minute and the tolerances given will often be exceeded for short periods. While one or two may be maintained at the expense of the others, it does not represent good operation for it throws an undue burden on all auxiliaries as well as the control, increases maintenance and fails to take advantage of the inherent heat storage and steam accumulator effect which acts as a thermal flywheel on the steam generating system.

When a standard control does not give the performance expected the burden of proof usually lies with the control manufacturer and this places undue responsibility upon him. While the control may be at fault due to poor arrangement, installation or adjustment for which he is not responsible, the difficulty more often lies with improper operation, the failure of some auxiliary to perform as expected, or the failure of the designer to anticipate control requirements or the effect of one piece of equipment on another. In no case should the manufacturer be expected to assume the entire responsibility for the performance of the whole plant. Much trouble can be avoided by having the manufacturer check the installation drawings, supervise the erection, check adjustments and instruct the operators.

SECTION 2F

Markings or identification which must be complied with for identification by, and in, the Purchaser's organization or to comply with standard company purchasing procedure.

A thorough comparison of proposals can be made only by detailed study of each control. The data outlined is in general included by all control manufacturers as a matter of course in accordance with individual company standards.

As a rule standard equipment which is available at any supply house is not ordinarily included by the manufacturer in the proposal price because it can usually be purchased by the customer, separately or in conjunction with the contract for installation and erection. Due to the difference in operating principles of the different controls the quantity of this standard equipment not ordinarily supplied varies from a negligible amount to a considerable percentage of the total cost. Some customers insist on purchasing the control complete, others prefer to take advantage of the savings.

Table IV. Summary to be included as first sheet of Proposal.

PROPOSAL FOR AUTOMATIC COMBUSTION CONTROL
BLANK MFG. CO., POWER HOUSE NO. 2.
SPECIFICATION NO. 1001A.

1. CONTRACTOR'S NAME	.....
2. SHIPPING POINT (City and State)	.....
3. PRICE, f.o.b. Factory:	
A. Automatic combustion and appurtenances less panel	$.....
B. Panel or panels minus instruments and controls included above	$.....
C. Total Price	$.....
4. CONTRACTOR'S REPRESENTATIVE. Living expenses, traveling expenses from.....(City and State) plus a per diem rate of	$.....
5. OVERALL DIMENSIONS of suggested panel: a. Height	..... ft..... in.
b. Width	..... ft..... in.
c. Depth	..... ft..... in.
6. ESTIMATED WEIGHT of Panel installed	.....lb.
7. ESTIMATED SHIPPING WEIGHT, complete control and panel	.....lb.
8. TIME REQUIRED:	
A. After contract is signed and full information furnished, for submission of standard outline prints and diagrams necessary to enable the Engineer to proceed with the installation drawings.	.....da.
B. For shipment, after receipt of full information	.....wk.
9. GUARANTEED PERFORMANCE TOLERANCES:	
A. Steam pressure	.....per cent
B. Furnace pressure	.....in. w.g.
C. Load division	.....per cent
D. Combustion: (either a or b)	
a. CO_2	.....per cent
b. Excess air	.....per cent

TABLE IV

This will vary in detail with individual needs. The form given is convenient for a quick and superficial comparison of bids for it gives a complete summary of all pertinent and essential data. Included as a separate sheet all price data can easily be removed from copies intended for general examination.

SECTION 3. GENERAL FEATURES OF THE PLANT AND CONTROL PROBLEM.

3A. BOILER ROOM. **Boilers and auxiliaries with which the control equipment is to be used are described in detail later and the plant layout is shown by the drawings, Figs. 7 and 8. Construction has been under way for several months and the plant is expected to be in operation by September, 1940. The general arrangement of auxiliaries, ducts and design is fixed but where practical minor changes will be made to accommodate the control or simplify the control problem. The initial installation will consist of two, 65,000 lb. per hr., Commodore bent tube boilers with normal steam conditions of 450 lb. ga., 550 deg. F. at the header. Each boiler is fired by pulverized coal from two Climax unit pulverizers of the high speed, no coal storage type with the fuel supply controlled from the raw coal feeders through a variable speed feeder motor. Each pulverizer supplies one Climax burner, making a total of two burners per boiler.**

Boilers are complete with economizers, convection superheaters, tubular type air heaters, one Cyclops forced draft and one Universal induced draft fan for each boiler. Each forced draft fan will be driven by an induction motor and has inlet control vanes. Induced draft fans will each be driven by a two speed induction motor and will have control dampers in the discharge duct. The arrangement contemplates manual change of motor speed and automatic operation of the damper. Gases, from both boilers, are discharged by the induced draft fans through a breeching to a single stack, 8 ft. I.D. at the top and extending 190 ft. above the center line of the burners. It is estimated that the natural draft will be sufficient to carry a steam load of from 20,000 to 25,000 lb. per hr.

Eventually the plant will be extended to the north and the control should be designed so that two more boilers, which may or may not be the same type and size as the original two, can be added later with minimum expense. The same chimney will serve all four boilers.

3B. LOAD AND CONTROL OPERATING CONDITIONS. **The combustion control equipment will be required for continuous operation, 24 hr. a day, 7 da. a week for periods of 4 mo. or longer. It may be of the air, oil, water or electric operated type, designed to operate the boilers automatically over a load range of from 20,000 to 80,000 lb. per hr. per boiler. **The arrangement should be such that all control functions, adjustments and push button stations for all motor driven auxiliaries are centralized on a control board to be located as shown by Fig. 7. Normally when two boilers are operating the total steam load will be evenly divided between them** but it would be advantageous to provide for uneven distribution of load should that prove desirable later under certain operating conditions.**

Due to requirements of high pressure steam used in process work the header pressure should be held as constant as practical over the whole load range. Furnace pressure or draft may be held constant and slightly below atmospheric pressure, or may tend to become slightly more negative at high loads depending upon the characteristics of the regulator used, provided the pressure variations are kept within the tolerances given in the guarantee requirements. Other control requirements in connection with each auxiliary are given in the following section under the heading the Detailed Description of the Equipment and Specific Control Problems.

A small but important part of the steam from the boilers will be used at high pressure in the manufacturing process but the largest proportion will be used for electric power generation in a 5000 kw. extraction-condensing turbine and for low pressure prime movers and process. Low pressure steam will be supplied either from a 125 lb. ga. pressure extraction opening on the turbine or through

SECTION 3A

General description of equipment to be controlled. If this section is properly done an experienced control engineer can determine the general requirements and arrangement of the required control without proceeding further. Additional data is needed only to fill in the details of the general plan.

Is plant in operation? If not, what is the expected date of operation? Can minor or major changes still be made in the plant design?

While it is advisable for the engineer to consult with control manufacturers while the plant is being designed, a detailed study of the specification by all manufacturers often brings to light points overlooked by the designer. Even minor changes may sometimes result in simplification of the control problem for one or all manufacturers. If the auxiliaries are not yet installed the possibility of substantial improvement is that much greater.

Boilers: number; capacity each; manufacturer; type steam pressure steam temperature method of firing.

Are economizers, superheaters, air heaters, or dust collectors provided? Are there any control problems involved with them.

Auxiliaries: make, number and type of fuel firing equipment such as: pulverizers, burners, stokers, etc., and method of fuel control. Make, number, type, drive and control of forced and induced draft fans. Breeching and stack arrangement; provisions for natural draft operation.

Plant conditions present or future that must be provided for and may influence control arrangement.

SECTION 3B

Expected service—Continuous or intermittent operation?

Operating medium—any preference?

General arrangement—Is a panel and centralized control desired?

Operating requirements—method of operation, steam pressure, furnace pressure. Maximum or minimum rating controls. Distribution of load between boilers. What should the control do on failure of operating medium?

What is the steam used for?

Load conditions—constant or variable?

Average load.

Peak and minimum loads.

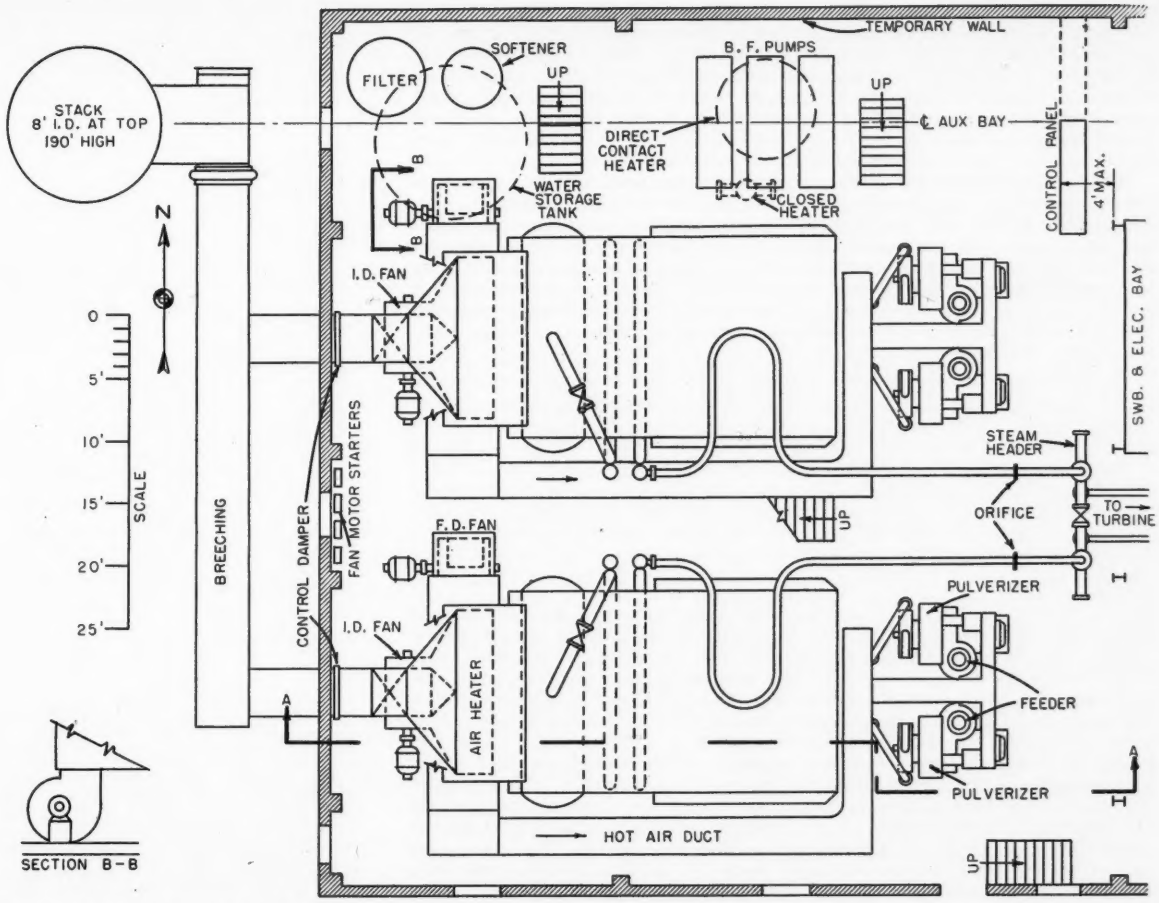
Maximum rate of load change.

Departure from normal load conditions.

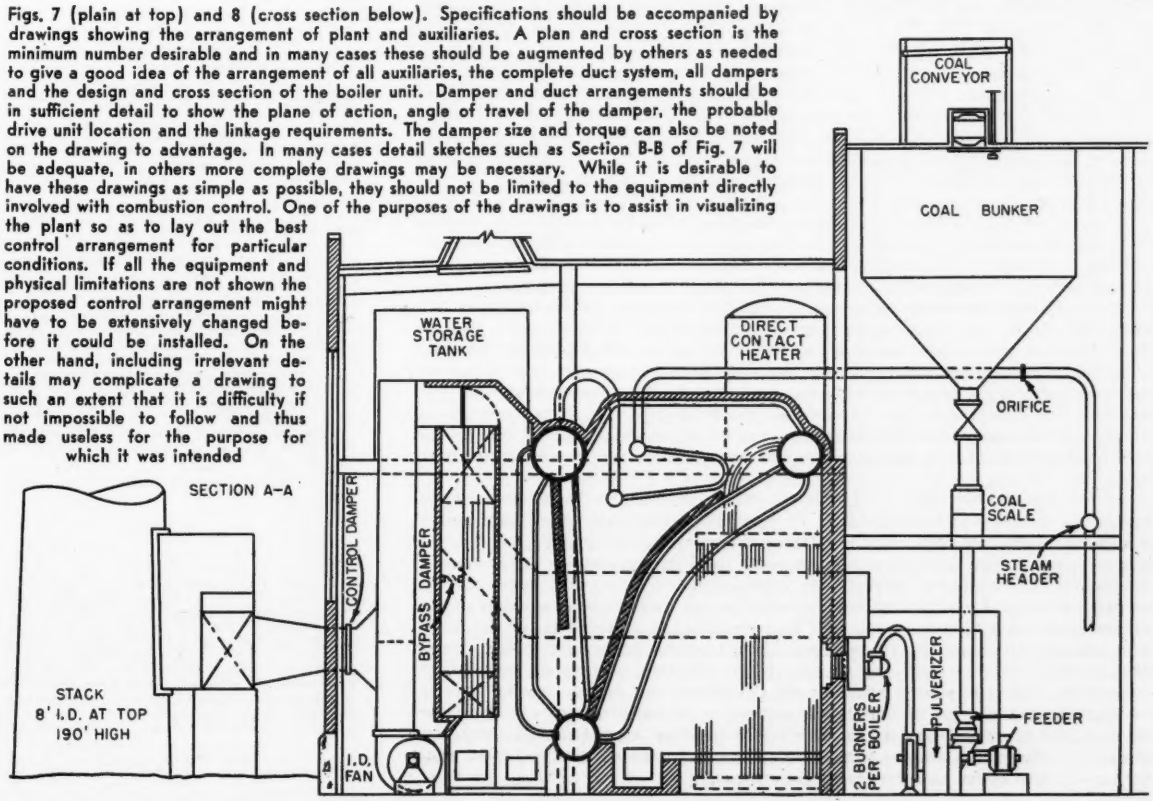
Range of load expected on automatic operation for each boiler or all boilers.

Expected method of operation under different conditions.

Reasons for selection of different equipment to meet operating conditions.



Figs. 7 (plain at top) and 8 (cross section below). Specifications should be accompanied by drawings showing the arrangement of plant and auxiliaries. A plan and cross section is the minimum number desirable and in many cases these should be augmented by others as needed to give a good idea of the arrangement of all auxiliaries, the complete duct system, all dampers and the design and cross section of the boiler unit. Damper and duct arrangements should be in sufficient detail to show the plane of action, angle of travel of the damper, the probable drive unit location and the linkage requirements. The damper size and torque can also be noted on the drawing to advantage. In many cases detail sketches such as Section B-B of Fig. 7 will be adequate, in others more complete drawings may be necessary. While it is desirable to have these drawings as simple as possible, they should not be limited to the equipment directly involved with combustion control. One of the purposes of the drawings is to assist in visualizing the plant so as to lay out the best control arrangement for particular conditions. If all the equipment and physical limitations are not shown the proposed control arrangement might have to be extensively changed before it could be installed. On the other hand, including irrelevant details may complicate a drawing to such an extent that it is difficulty if not impossible to follow and thus made useless for the purpose for which it was intended



a reducing valve and desuperheater station between the 450 lb. ga., 550 deg. F. header and the 125 lb. ga. saturated steam system. The average steam load is about 90,000 lb. per hr. but both the electric and process steam demands are variable and the total steam load ranges from 50,000 to 145,000 lb. per hr. Under some conditions the load swing, from minimum to maximum or from maximum to minimum, takes place in from 8 to 10 min. Normally two boilers will carry this load with a range on each boiler of from 25,000 to 72,500 lb. per hr.

During certain extended periods of operation the total load drops to from 22,000 to 45,000 with infrequent peaks up as high as 70,000 lb. of steam per hr. During these periods only one boiler will be used with one pulverizer in operation and the induced draft fan running at low speed. The second pulverizer and high fan speed will be used only during peak periods and necessary changes will be made by the operator. Loads of below 20,000 lb. per hr. are reasonably constant and the boiler in use will be operated under complete or partial manual control, probably with natural draft as operating experience indicates advisable after the plant is completed and in service.

3C. FUEL. (Alt. 1.) *While the plant has been designed to burn several grades of bituminous coal, the fuel used under normal conditions will be a minus ¼ in. bituminous screenings from the Kinny Coal Co., Mine No. 6. The A.S.T.M. grindability of this coal is 58-63 and the ash softening temperature, 2225 deg. F. A typical analysis shows a heating value, dry, of 13,580 B.t.u. per lb., and the following proximate analysis in per cent: Volatile 33.54; fixed carbon 50.27; ash 8.38; moisture 7.81. Past records show that the moisture as fired ranges from 5 to 10 per cent. The ultimate analysis used in gas calculations was: sulphur, 2.36; hydrogen, 5.31; carbon, 67.40; nitrogen, 1.44; oxygen, 15.11. A light fuel oil will be used for starting up and very light loads, but always under manual control.*

SECTION 3C

Fuel or fuels used—Coal, Gas or Oil.

Probable usual source of supply, field or mine: Heating value. Ultimate analysis for flue gas calculations.

Coal: size, grindability, proximate analysis, ash fusing or softening temperature.

Oil: viscosity and temperature delivered to the burners, gravity.

Gas: specific gravity for valve calculations, pressure and temperature at which volumetric determinations are made.

Provision for standby fuel. Is it to be considered in the control?

3D. AUXILIARY POWER. All fans, two boiler feed pumps, one fuel oil pump and all pulverizer motors are driven by alternating current through separate feeder circuits from two 440 v., 3 ph., 60 cycle auxiliary busses in the generator room. These busses are arranged for automatic changeover in case of electrical disturbances. The power supply is reliable for the plant is tied in electrically with one other plant and part of the electric load is carried by the public utility system. Direct current for the feeder motors is supplied from a 125 v., 10 kw. motor generator set. Control circuits, emergency lighting circuits, control and pilot motors are supplied at 125 v. from a storage battery equipped with a trickle charger. Auxiliary motor starters involved with the control are all of the full voltage starting type with time delay relays adjustable up to a maximum of 4 sec., to prevent the auxiliaries from dropping out on momentary voltage dips. The power system, starter boxes, fixtures and other parts are grounded in accordance with the National Electric Code. Control circuits are ungrounded. The only steam driven auxiliaries are the fuel oil pump and turbine driven boiler feed pump. The first is supplied from the 125 lb. saturated steam system and the second from the 450 lb., 550 deg. F. header. Both exhaust at 5 lb. ga.

SECTION 3D

Electric: Voltage, phase, frequency of a.c. and voltage of d.c., power used for driving different auxiliary motors used on control circuits, etc. Source and capacity of various power supplies. Is the power supply reliable? Is automatic changeover of auxiliary busses provided or do auxiliaries trip out on power interruptions? General type of starters used on essential auxiliaries; provisions for momentary voltage dips. Are power and control circuits and equipment grounded or ungrounded?

Steam: Pressure and temperature at throttle and exhaust pressure of steam auxiliary drives.

3E. SERVICES AVAILABLE. Electric power, compressed air and water services are available for use with the control. Alternating current at 440 v., 3 ph., 60 cycle may be taken from the auxiliary bus and at 110 v., 60 cycle single phase from the lighting circuits. Not over 3 kw. of 125 v. direct current is available for use from the motor generator set. Direct current at 125 v. from the storage battery for control and emergency lighting circuits is limited and can be used only for pilot motor operation.

Compressed air is furnished to the power plant at 95 lb. ga. from the regular plant system supplied by steam and motor driven compressors with adequate receivers. It is reliable, reasonably free from dirt, moisture and oil but is not considered suitable for use in the control system without filters and dryers.

Water is available from three sources and the pressures given are those normally obtained at the operating floor level. Service water at 55 lb. ga. is pumped from the lake, has a total hardness of about 20 g.p.g. and is not filtered. The system is, however, equipped with an adequate overhead storage for emergency operation. Drinking water from the city mains at 60 lb. pressure is filtered, partially treated, and has a total hardness of about 12 g.p.g. There is no overhead storage on this system but the service is reliable. City water treated and filtered for boiler feed makeup is stored in tanks about 40 ft. above the operating floor level.

SECTION 3E

Electric power, compressed air and water services available for use with control and which may be used to avoid duplicate equipment together with any limitation on their use.

Electric power: Voltage, phase and frequency of a.c., and voltage of d.c. power. Where available? Is use limited?

Compressed air: Pressure, quantity, condition and reliability. An air operated control requires a small, but clean, dry and reliable supply.

Water: Can sometimes be used to advantage if the supply is soft, filtered and reliable. Give pressure, source, hardness, reliability and any other data available on scale forming and corrosive properties.

Oil: Used in larger systems but with a separate supply pump. Seldom if ever available in a plant. Give data for available supplies as for air.

Steam: Used seldom and only on the simpler controls. Usually taken from the boiler.

3F. PROVISIONS FOR MOUNTING. The erection and installation of the control will be made by the Purchaser. In general the plant design and arrangement contemplates the installation of regulators or power operating units, as the case may be, on the floor, wall or column adjacent to or directly under the damper or machine to be controlled. There is no basement under the boiler room and the electric cables and conduit will be carried to the approximate location of the various auxiliary motors in a system of floor trenches. From the sides of the trench 2 in. conduit imbedded in the concrete runs to each motor and motor starter. Similar conduits run from the trench to the location considered suitable for installation of the necessary control unit. Necessary air, oil or electric lines for the control may be run in the trench system, or, if more convenient, supported on the underside of the grating, similar to the lighting conduits. When cable and shafting is involved it will be carried along the underside of the grating or along the side of the boiler as found most convenient.

SECTION 3F

What provisions have been made by the designer for mounting and installing the different regulators and power operating members? While no detailed arrangements can be made until a control system has been selected, some consideration must be given to this problem in the early stages of design if a satisfactory installation is to be made without undue expense for changes.

SECTION 3G

What interlock and safety features incorporated in plant or auxiliary design or arrangement? This may or may not influence the control. Separate electrical interlocks are a common safety feature on pulverized coal plants with motor driven auxiliaries. Modification can be made for use with steam drives and with gas and oil firing. Stokers are in general less critical under emergency conditions and interlocks if used are less extensive. The interlock may, if desired, be incorporated entirely or partially in the control system. The usual electrical interlock protects against motor failure but not against failure of a coupling or transmission or a damper turning on its shaft. If necessary, mechanical or a combination of mechanical and electrical interlocks can be used.

3G. INTERLOCKS. **A separate electrical interlock system is provided, operating from contacts on the motor starters and arranged for the proper starting and stopping sequence of the motor driven auxiliaries under either normal or emergency conditions. The starting sequence is (1) induced draft fan; (2) forced draft fan; (3) pulverizer and primary air fan; (4) feeders. The stopping sequence is the reverse of this. Failure of any motor stops everything farther down the list. Thus, failure of a feeder trips out nothing else, but failure of the induced draft fan trips out all the other equipment. Cutout switches to render the interlock inoperative are not provided and the equipment can be operated individually only by using temporary shunts. This system was designed by the MacKenzie Electrical Co., 1827 E. Van Buren St., Chicago, Ill. Each burner also has a Plico flame protection device made by the Hiller Specialty Co., Kankakee, Ill. Upon loss of ignition this device closes a damper in the coal-air mixture duct immediately preceding the burner and at the same time trips out the pulverizer and feeder motors.**

SECTION 4. DETAILED DESCRIPTION OF EQUIPMENT AND SPECIFIC CONTROL REQUIREMENTS.

SECTION 4A

Make, type and number of boilers and both continuous and peak capacity.

Drum design pressure. Steam pressure and temperature at header. Maximum pressure drop through superheater and piping at maximum capacity.

Boiler and water wall surface heating and arrangement. Furnace volume. Heat release.

Baffling. Draft loss from furnace to induced draft fan, broken down between boiler, economizer, air heater and cinder catcher.

Boiler efficiency at three or four loads including the maximum.

4A. BOILERS. **The two boilers are Commodore Class XX, each with a continuous steaming capacity of 65,000, and a maximum 2 hr. peak capacity of 80,000 lb. per hr. at the normal operating conditions of 450 lb. ga. 550 deg. F. total temperature at the header. Boilers are designed for a maximum pressure of 510 lb. per sq. in. ga. and the pressure drop from the drum through the superheater and piping to the header is estimated as 25 lb. at maximum output. Each boiler has 7820 sq. ft. of boiler heating surface, 1020 sq. ft. of projected water wall surface on two sides of the furnace and 3850 cu. ft. of furnace volume. The heat release at maximum load is about 25,000 B.t.u. per cu. ft. per hr. Each boiler is baffled for three passes and the draft loss from the furnace to the suction of the induced draft fan will be 4.6 in. of water at maximum output, 2.1 in. of which is draft loss across the gas side of the air heater. The overall boiler efficiency is about: 85.0 per cent at 80,000 lb. per hr.; 85.5 per cent at 65,000 lb. per hr. and 84.8 per cent at 32,500 lb. per hr.**

SECTION 4B

Make, type, heating surface and arrangement.

4B. ECONOMIZERS. **A small amount of economizer heating surface is built integral with the last pass of each boiler and requires no control beyond that provided by the feedwater regulator.**

SECTION 4C

Make, type, heating surface, arrangement, steam temperature and variation with load.

Is temperature control needed? Temperature control is used only on the larger high temperature units. Bypass control with dampers is the most popular and may be either manual or automatic.

4C. SUPERHEATERS. **Each boiler has a 220 sq ft. Commodore convection type superheater located between the first and second passes. The superheaters are designed to give a total steam temperature of 550 deg. F. at a boiler output of 65,000, and 570 deg. F. at 80,000 lb. per hr. No provision has been made for temperature control beyond that provided by the natural characteristics of a superheater of this type.**

SECTION 4D

Make, type, heating surface, gas and air temperature.

Draft loss on air and gas sides. Any damper or other device in connection with the air heater which would tend to make measurements erratic.

Dampers and arrangement. Include both those intended for manual and automatic control. Give full details of size and construction (See Sec. 4H and 4J) of those which must be handled by the control for either automatic or remote operation.

4D. AIR HEATERS. **Gases from each boiler will pass through a 6550 sq. ft. Commodore tubular air heater which will heat the incoming air for combustion from about 80 deg. F. to a maximum temperature of 420 deg. F. at full load. The gases enter the air heater at 650 deg. F. and leave at 400 deg. F., and the draft loss at maximum load is 1.7 in. w.g. on the air side. The air heaters are equipped with bypass ducts and dampers to provide regulation of the air temperature at high loads, gas temperature at low load and operation on natural draft. When necessary, these dampers will be manually operated and need not be considered in connection with the automatic combustion control.**

SECTION 4E

Feedwater pump and supply pressure.

Feedwater heaters used and feedwater temperature variations at different loads.

Feedwater regulator arrangements. If regulator is to be supplied as part of the combustion control give additional data on size, flanges, pipe arrangement and method of operation. Some regulators, operating independent of the combustion control, have a remote control located on the control panel in order to change the water drum level as desired.

4E. FEEDWATER. **Feedwater is supplied at about 550 lb. pressure by two motor and one turbine driven centrifugal boiler feed pumps. These pumps take their suction from a direct contact heater, supplied with steam from the 5 lb. ga. system, and pump through a high pressure closed heater, supplied with steam from the 125 lb. ga. system. Normally the feedwater temperature is nearly constant at about 346 deg. F. for all loads. The 125 lb. steam is used primarily for process in an older section of the plant which is sometimes out of service for several weeks at a time. During these periods the automatic extraction valve on the turbine is fixed in the wide open position and the steam pressure to the high pressure heater varies with the load so the feedwater temperature ranges from about 250 deg. F. at light load to 345 deg. F. at full load. Each boiler will have an Acme feedwater regulator and excess pressure control. The feedwater regulator does not have to be considered in connection with the automatic combustion control beyond provision for adjustment of the relation between furnace heat release and steam output made necessary by the variation in feedwater temperature with load during the periods mentioned.**

SECTION 4F

Dust collectors if used are located on the suction side of the induced draft fan in order to reduce fan blade erosion. Some require no control and some do. In certain bases the latter may be involved with and complicate the combustion control.

If a dust collector is installed give make, type, size and details of arrangement and control expected.

4F. FLY ASH COLLECTOR. **No fly ash collectors or cinder traps will be provided initially but the ducts and auxiliaries are arranged so that if necessary a Davis multiple cyclone type collector can be added later, outside the building adjacent to the west wall. When and if installed, automatic control will be provided to maintain a constant gas velocity through the collector by opening and closing dampers in accordance with load. It is expected that this control will be separate from the automatic combustion control. If it will influence the latter the Contractor should make provision for it in his design.**

SECTION 4Ga

Pulverizers: number, make, type, size, capacity with type of coal to be used.

Drive: make, type, size, speed and connection to mill, starter details and location.

If starting control on any auxiliary is to be on the panel, include sufficient data on starter to identify it in manufacturer's catalog.

4G. FUEL SUPPLY TO FURNACE. (Alt. 1) a. PULVERIZERS AND DRIVES. *Four Climax No. 140 unit pulverizers will be installed, two for each boiler, each mill with a maximum capacity of 5700 lb. per hr. of Kinny No. 6 coal. Each pulverizer is V-belted to a 75 hp., 1750 r.p.m. Phoenix constant speed induction motor with a Phoenix Style 7689 across-the-line starter arranged for remote push button ope-*

*ration. The push button stations are Phoenix Cat. No. 1736D **and are to be mounted on the control panel.*

b. BURNERS. *Each of the four pulverizers will supply one Climax No. 17 Combination burner having a maximum capacity of 5800 lb. of coal per hr. and a range of 5 to 1 with stable ignition. Secondary air dampers at each burner will be adjusted by the operator. Fuel oil will be burned only while starting up or on light loads and always under manual operation.*

c. FEEDERS AND FUEL CONTROL. *Each of the four mills is equipped with a Climax Size 6, rotating table type raw coal feeder, with a knife or plow and a two speed gear box. Each feeder is driven through the gears and a sprocket by a Phoenix, Type KC, 1 hp., 125 v., d.c. shunt wound motor with a speed range of from 500 to 2000 r.p.m. so as to give a table speed of from 9 to 36 rp.m. With uniform coal quality and fineness and a fixed position of the plow, there is a straight line relation between the feeder speed and coal feed. It is not expected that the gear box will be needed in regular operation but if necessary the shift will be made by the operator so as to change the speed range of the table to 4 to 16 r.p.m. The feeder motor starters are Phoenix, Style 986, magnetic type arranged for remote push button* operation through Phoenix Cat. No. 1736F stations to be mounted on the control panel.*

*Control of the rate of fuel feed will be through the feeder motor speed by full field control. The four individual field rheostats shall be supplied by the Contractor as part of the control. Each shall have approximately 70 speed steps and be arranged with the control so that: all feeders can be operated at the same or at different speeds should this be made desirable by uneven wear on the pulverizers; and either one or two pulverizers on a boiler can be operated under automatic control. **Eight ammeters and eight push button stations for the pulverizer and feeder motors will be supplied by the Purchaser and are to be mounted on the panel. All of these push button stations incorporate pilot lights to show when the respective motors are operating. The Contractor shall, however, supply as part of the control and arrange for mounting on the panel, signal lights operated by contacts at both extremes of the rheostat travel, or, other comparable devices, so as to indicate to the operator the need for changing the feeder gear box or the knife position. **This type of mill involves a time lag between the feeder and burner and the control shall incorporate some means of compensating for this so as to avoid a deficiency of air and resulting smoke when the load drops rapidly. This lag is estimated at a maximum of 20 sec. for a sudden change from full to minimum load. Means shall be provided on, or in conjunction with, all regulators involved to prevent fires being extinguished in case the load is dropped suddenly and to prevent any controlled device traveling beyond the minimum or maximum safe or desirable load limit set by induced draft, forced draft, pulverizers or feeders, as the case may be. Necessary electrical contacts, on auxiliary and other equipment beyond the combustion control, will be provided by the Purchaser.*

d. **METERING CONNECTION. *Should the table speed be used as an indication of the coal feed, the 2 in. worm gear shaft, which drives the feeder table and extends about 2½ in. beyond the drive sprocket and may be used for mounting a tachometer pulley or sprocket not more than 6 in. in diameter. This shaft has a ¼ in. keyway, $\frac{3}{16}$ in. deep, and the normal speed range is from 250 to 1000 r.p.m.*

e. PRIMARY AIR. *The four primary air fans, one for the outlet side of each of the four mills, are Climax 3000 c.f.m., Type 1, Size 3, each driven from its respective pulverizer shaft and designed to give a pressure of 9.5 in w.g. at the burners. Drying air for each mill is taken from the burner windbox with the temperature regulated by tempering with air from the boiler room through an inlet damper at the entrance to the mill. Both the mill inlet air temperature and pressure will be regulated by the operator.*

4H. AIR SUPPLY TO FURNACE. (Alt. 1). a. FANS. *Two Cyclops Type X, Size 3, forced draft fans with inlet vane control are provided, one for each boiler. Each fan has a capacity of 23,700 c.f.m. of 100 deg. F. air at 8 in. w.g. static pressure and a speed of 1750 r.p.m. The fans discharge vertically upward to the air heater duct.*

b. DRIVES. *Each fan will be driven through a flexible coupling by a direct Phoenix Type CH, 440 v., 3 ph., 60 cycle, 1750 r.p.m., 50 hp. induction motor with a Phoenix Style 1836 across-the-line starter arranged for remote operation from a Phoenix Cat. No. 1736D push button station **to be mounted on the panel.*

c. CONTROL AND DAMPERS. *Control of the forced draft will be accomplished through movement of the fan inlet vanes by the automatic control. These follow standard Cyclops Fan Co. construction with all vanes synchronized and operated by a single bell crank turning through a maximum arc of 90 deg. in a plane at right angles to the fan shaft. The operating end of the crank is 9 in. long and in mid position is horizontal and about 38 in. above the floor. The manufacturer estimates that an operating torque of 100 ft. lb. is sufficient to operate the vanes even under adverse conditions. The control power unit may be mounted on the floor directly below the lever. **The fan motors will be started and stopped from push button stations on the control panel.*

4J. GAS REMOVAL FROM FURNACE. (Alt. 1). a. FANS. *Two Universal, Class XII, No. 4 induced draft fans are provided, one for each boiler. Each fan has a maximum capacity of 40,200 c.f.m. of 450 deg. F. gas at 8.7 in. w.g. total resistance at the higher speed of 1150 r.p.m. and 29,700 c.f.m. at 4.9 in. w.g. total*

Gas and Oil: Supply facilities, piping arrangement, pressures, temperature pump, pipe and valve size and arrangement. Stokers: see section 4Gc and alternate sections.

SECTION 4Gb

Coal Burners: Number, make, type, size, maximum and minimum capacity, primary and secondary air control dampers. Provision for other fuels whether used with manual or automatic control.

Gas and Oil Burners: Same data as for coal—see alternate sections. When natural draft is used add draft loss across the burner at maximum load.

SECTION 4Gc

Feeders and Stokers: Make, number, type, size, minimum and maximum capacity or speed. Is gear box provided? What is the effect on speed or change? Is it used in normal service? Is it to be controlled automatically? Automatic control of gear boxes is possible but awkward.

Drive and starter—See 4Ga above—With small variable speed motors the rheostat is often left for the Contractor to supply so it may be well adapted to his control. If this is done, give necessary speed and control requirements. If it is purchased elsewhere, give sufficient data to identify it in manufacturer's catalog.

Fuel Control. Is the combustion control concerned with the raw coal feed, the pulverized coal feed, or both? What dampers are involved? Are they manually or automatically operated? In many cases the feeder and feeder control are supplied with the mill and have a control independent of the combustion control. In this case the control manufacturer is interested in feeder data only to definitely identify the equipment so as to decide how it affects the combustion control. With any arrangement full details of the actual method of fuel control to the furnace is necessary, amplified as needed by additional detail sketches. When dampers are involved with automatic control, include data as in Section 4Jc, Alt. 1.

What extras are to be supplied with the control? What is to be incorporated in the panel? What safety or operating convenience features are to be provided?

SECTION 4Gd

How can fuel be metered? With some stokers and pulverizer feeders the speed, used as an indication of fuel flow, may be measured by a small blower or electric type tachometer. Mention details of possible drives for such a device with the speed range of shaft, size, length and keyways. See alternate sections.

SECTION 4Ge

What is the source of primary air supply? Pressure and temperature? How are these regulated? If a separate fan is used give: make, type, size, drive, capacity, air pressure and whether on inlet or outlet of mill. Provision for manual or automatic control of air pressure and temperature at mill inlet.

SECTIONS 4H and 4J

Forced and induced draft fan data needed is essentially of the same type although the details may be different. With both include the following:

SECTIONS 4Ha and 4Ja

Fans: Make, size, type, total number and number per boiler.

Rated capacity with pressure, temperature and speed; if driven by multispeed motors, include data for each speed.

Duct arrangement if needed to amplify drawings.

SECTIONS 4Hb and 4Jb

Drives: Make, horsepower, voltage characteristics or steam pressure and temperature, speed and speed range, connection to fan, starter details. What provision is to be made for starting, stopping, speed control and panel details. With steam drives include also: pressure and temperature at throttle, steam chest or nozzle pressure and steam flow at full load, pipe size and length, governor or speed control valve details. Is valve to be supplied with control? If so, what flange drilling is wanted and what pressure drops are allowable.

SECTIONS 4Hc and 4Jc

Variable speed transmissions. When variable speed transmission is used, give specific details as covered in alternate sections. In general this covers: Make, type, size, maximum and minimum speed. Method of control, operating torque, lever lengths, arc and plane of travel.

What is the duct arrangement? What dampers are provided? Which are for manual and which automatic operation?

When dampers are to be automatically controlled give: Make (or fabricator) and details of construction with the number of blades, type of bearings, sealing strips. Do all blades move parallel to each other or do alternate blades move in opposite directions?

Frame size: net area full open. Pressure differential and velocity wide open with maximum flow. Maximum pressure differential possible across the damper when closed.

Torque required, details of operating levers and lever arm length. Arc of operation if other than 90 deg. Are there any restrictions in operation?

Can a counterweight be used? Where can the control operating unit or regulator be conveniently located?

The last two paragraphs of Section 4Jc deal with typical details needed in specific cases and these will vary with the plant. What safety features are wanted? How are the motor starters to be controlled? What is to go on the panel? What operating conveniences, like the damper signals, are wanted? Remember all these details add to the cost and if money is limited the control must be restricted to bare essentials. Many of the extra features are included as standard construction on some controls but not on others, so that the only way of insuring proposals on comparable equipment is to specify definitely what is wanted.

SECTION 4K

Specific requirements of the control panel or panels: location in plant; space limitations especially as to depth; construction—open back or enclosed; arrangement of piping and wiring connections; mounting and style of instruments; provision for lighting. Adequate panel lighting is extremely important from the standpoint of the operator and should be given special consideration by the designer.

Arrangement: number and location of panels; list of instruments and parts such as push buttons, signals, remote controls, etc., to be provided for beyond the actual combustion control; instrument name plates; are additional parts to be supplied by Contractor or Purchaser?

Many items covering commonly used pressure, temperature, flow, water level, smoke and draft measuring instruments and firing guides were omitted for brevity and to avoid any suggestion of recommended practice. Items used were included simply to illustrate the type of information needed when additional equipment is purchased with the control or when purchased separately with the intention of incorporating it in the instrument panel. Items omitted cannot be standardized for any type of plant but vary with the money available, the opinion of the designing and operating engineers and the general policy of the company in connection with records and accounting practice. As a rule they involve indicating, recording and integrating types and are purchased on a separate

resistance at the lower speed of 850 r.p.m. Each fan takes the gas from the lower end of the one air heater and discharges upward through a duct and damper to an outdoor breeching connecting with the stack.

b. DRIVES. *Each of the fans is driven through a flexible coupling by a Phoenix Type AH, 440 v., 3 ph., 60 cycle, 75/30 hp., 1150/850 r.p.m. two speed induction motor equipped with a Phoenix Style 1428 across-the-line starter arranged for remote operation **from the panel by Phoenix Cat. No. 1736G push button stations. These motors incorporate a centrifugal switch to automatically take care of the deceleration period when changing from high to low speed.*

c. CONTROL AND DAMPERS. *Control of the induced draft will be by a combination of fan speed and damper, the fan speed to be changed by the operator and the damper by the automatic control. The damper for each fan is set in a vertical plane in the duct, with the shorter side and the shafts horizontal and all blades moving in the same direction parallel to each other. These dampers, fabricated by the Michigan Iron Works, Racine, Wis., have four blades, sealed stuffing boxes with external dust proof ball bearings, sealing strips on the blades and duct and dividing plates between the blades. The measure 36 by 44 in. inside and the maximum net area is about 9.5 sq. ft., giving maximum gas velocity of about 70 ft. per sec At maximum flow and 85 deg. open, the pressure loss across the damper as calculated is approximately 0.2 in. w.g. Over the normal load range they will move from about 12 to 60 degrees as extremes and be open 25-30 deg. at average load. The control, however, shall be designed to move over a full 90 deg. arc. Closed, the maximum possible pressure differential is 8.0 in. w.g. The required damper operating torque is estimated at 125 ft. lb. The wall limits the operating lever arm to a maximum length of 9 in. and prevents the use of a counterweight. The power operating unit can be conveniently installed on the concrete floor directly and about 15 ft., below the damper, on a pedestal below the damper, or, on the adjacent wall at any convenient location.*

***Two push button stations for starting, stopping and changing speed of the two fan motors will be supplied by the Purchaser and are to be incorporated on the control panel. Signal lights or other suitable devices to show the operator when the dampers are approaching an open or closed position and indicating a need for change of motor speed shall be incorporated in the push button stations or located adjacent to them on the control panel. Signals with the necessary contacts enclosed suitably protected and adjustable to damper operation as determined in service shall be supplied by the Contractor as part of the combustion control.*

There is no objection to automatic control of both motor speed and damper position and the Contractor may, if he wishes, submit an alternate proposal. This should be identified as Alternate A and given as an addition to the main proposal price. Any such arrangement must incorporate all the features enumerated above and in addition provide for an overlap in damper travel opening and closing to prevent unnecessary changes in motor speeds at certain loads. Also in order to avoid undesirable pressure fluctuations when changing motor speeds, the regulator controlling the damper shall be provided with a device for quickly and automatically repositioning the damper in accordance with the natural acceleration and deceleration curves of the fan and motor.

Gas and air bypass dampers, provided in the design to allow natural draft operation, will be changed as needed by the operator. Control of gas flow and furnace pressure under natural draft will be under remote control using the same regulator and breeching damper as in normal operation.

4K. **CONTROL BOARD. **a. Location and Design. The control shall be centralized on a panel to be located in front of the auxiliary bay facing the boilers as shown by Fig. 7. This panel should be self supporting and arranged for all external connections through the bottom. All instruments and parts should be designed for flush mounting with cases either black or consistent with other equipment and trim on the panel. Pipe tunnels limit the depth or distance from the wall to a maximum of 4 ft. but there are no restrictions on length or height. Both the control and panel should be designed so that two additional boilers can be added later at minimum expense. When this is done it is desired to have the centerline of the complete panel coincide with, and, if practical, be symmetrical about, the centerline of the auxiliary bay. General requirements of construction, arrangement and finish are covered earlier under Control, Proposal and Guarantee Requirements.**

b. **ADDITIONAL EQUIPMENT. **In addition to the instruments, regulators and other essential parts of the control which the Contractor must, or may elect to, provide for mounting on the control board, provision shall be made for the additional equipment listed below, which, unless otherwise noted, will be supplied by the Purchaser. This additional equipment may be mounted on the same panel as the control equipment or on a separate panel or panels as convenient for the Contractor. Each major instrument or control device on the board, which is not otherwise easily identified, shall have a legible name-plate as indicated below by quotation marks:**

ITEM 1. Master Clock. One. Clarke, Model A7, Size 4. Supplied by Purchaser. No name plate.

ITEM 2. "Steam Header Pressure". Indicating only. Range 0-800 lb. Shively Cat. No. 860. To be supplied by Contractor.

NOTE: Items 3 to 13 inclusive, covering pressure, temperature, flow, water level, smoke, and draft measuring instruments and firing guides have been omitted for brevity as they cover equipment usually purchased on a separate contract. They must, however, be identified by make, type, and size (including panel cutout and drilling dimensions) in the combustion control specifications so that the Contractor can design the instrument panel. When they are purchased with the control the specifications should give the desired range or scale reading as in Item 2 and also a specific designation if a certain size, make and type of instrument is wanted.

ITEM 14. Ammeters. Walker, Cat. No. 1897B, 3 in. Twelve, six for each boiler as follows: "Forced Draft Fan" motor, "Induced Draft Fan" motor, "Pulverizer No. 1" and "Pulverizer No. 2" motors, and "Feeder No. 1" and "Feeder No. 2" motors. Supplied by Purchaser.

ITEM 15. Push Button Stations. Fourteen, seven for each boiler. Twelve, complete with push button and pilot lights and designed to handle the starters for the following motors: "Forced Draft Fan"; "Induced Draft Fan"; "Pulverizer No. 1" and "Pulverizer No. 2"; "Feeder No. 1" and "Feeder No. 2". Space for the remaining two, intended for possible future use with motor operated steam valves, shall be provided with the panel cutout, the holes fitted with a neat cover and the name plate omitted. Supplied by Purchaser.

ITEM 16. Signals. Four or six sets, two or three for each boiler as needed in connection with the "Induced Draft Damper", "Feeder No. 1 Rheostats" and "Feeder No. 2 Rheostat". The damper signals shall indicate and be labeled "Open" and "Shut", the rheostat signal "Min" and "Max" feeder speeds.

SECTION 5. GENERAL CONTRACT REQUIREMENTS.

5A. CHANGES AND EXTRAS. Except as provided later, under "Alternate Proposals" no extras or additional compensation shall be allowed for changes, alterations or additions to the original proposal and obviously necessary for the satisfactory completion of the work for the purpose intended by other paragraphs. Changes in the specifications, due to errors or changes in the requirements, arrangement or design of the controlled equipment, will be valid only if made in writing by the Engineer. If these changes, made either before or after the contract is signed, alter, add to or deduct from the control, the price covered by the proposal or contract will be adjusted accordingly and the value of the change agreed upon immediately in writing. Definite information regarding changes desirable to meet the needs of specific control equipment should be obtained from the Engineer in writing before the proposals are due so full details of the change can be incorporated in the proposal submitted.

5B. ALTERNATE PROPOSALS. The Contractor may submit alternate proposals based on departures from these specifications, but, unless alternate proposals, departures from, and exceptions to, the specifications are specifically indicated in the first part of the proposal, submission of a bid will be considered as an agreement by the Contractor to comply with all the requirements of these specifications and drawings. Alternate propositions will be given full consideration, provided details of the alternate materials, or arrangement complete in all particulars and with the reasons for the change, is furnished.

5C. MISCELLANEOUS EQUIPMENT. The material covered by these specifications does not include ducts, dampers, damper levers, standard pipe and fittings, cable, conduit, steel shafting and linkage, copper tubing or electrical wiring except in connection with shop wiring of panels. It does include all special parts, cranks, universal and other joints, pulleys, clevises and bearings, as well as strainers, filters, and pressure reducing valves needed to utilize the services available. **The control shall be considered as starting at the master panel.

5D. MOTIVE POWER. Whether or not the elected medium for control or loading lines and operating members is available at the plant, the Contractor shall supply as part of an air or oil operated control, tanks or receiver as needed to insure manual or automatic operation of the regulators for a period of at least 10 min. after failure of the main motive power supply. If the medium elected is not available at the plant, the Contractor shall supply as part of the control, the necessary pumps, compressors, blowers or motor generator sets all complete with receivers, tanks, prime movers, starters, batteries, controls, etc., necessary to operate the combustion control in normal service and to provide 10 min. emergency operation after failure of the main motive power supply.

5E. SPEED AND POWER. Each regulator and its corresponding power operator shall, as a unit, be capable of traveling from one extreme to the other in not more than 45 sec. and have adjustments so that the sensitivity or rate of response can be changed as required by the service intended. The rated thrust or torque shall be available over the full stroke or arc of travel of the damper or mechanism which it operates. Where definite torque requirements are not given in the specifications and cannot be obtained from the Engineer, the Contractor shall supply a power unit which past experience indicates as adequate for the service.

5F. **INDIVIDUAL REGULATORS. In addition to the control as a whole, and other requirements provided for earlier, individual regulators, power operating units or both, as the case may be, shall be provided with adjustable limit stops or other means as necessary to prevent jamming or damage to the control or controlled equipment at either extreme of travel or damage from operating the control while the machine or prime mover is not operating. The means of contract or contracts. With few exceptions they are not involved with the combustion control. The usual exceptions are steam flow-air flow, CO_2, smoke meters, gas (fuel) flow-air flow, steam temperature recorders and steam flow meters.

The first three are, or may be, integral parts of some control systems and, if used in the control purchased, there is no necessity for duplicating them elsewhere. Their purchase may be delayed until after the control is purchased and the preliminary panel design based on one or two unknown instruments or they may be purchased with the control.

Steam flow and temperature recorders are involved only through the fact that steam flow and temperature pens can be conveniently incorporated in the other instruments to make a two or three pen recorder as the case may be.

Panel arrangement and design depends primarily upon the control selected and as this also influences the selection of instruments to a certain extent, an exact and final panel arrangement can seldom be made with the proposal. The proposed arrangement must be based on certain assumptions and the specifications should allow for the fact that many details, which may change the entire design, cannot be settled until after the contract is signed.

SECTION 5A

Section 5 as a whole deals with more or less standard contract provisions, some of which apply specifically to combustion control specifications, others of which apply to specifications for equipment of any kind. Section 5A in particular makes provision for changes in arrangement or design of the controlled equipment. This is extremely important for combustion control specifications are often prepared after all details are settled, in fact sometimes before the auxiliaries are purchased, so that proposals must be based upon certain assumptions which may later prove to be not valid.

SECTION 5B

Provision for alternate proposals should contractor feel that arrangement other than that covered by specifications would be simpler, cheaper or more desirable. Control manufacturers are ingenious and will undertake to solve successfully any control problem the customer is willing to pay for. They prefer to handle the details of a given control system as simply as possible, however, because a simple solution is more likely to be rugged, serviceable and cheap.

SECTION 5C

Standard materials which are available in any supply house are not usually included in the control contract because they can be purchased cheaper locally. Occasionally, however, these are purchased from the control contractor.

SECTION 5D

This section, while covering standard practice quite generally can, in specific cases, be made more definite because the requirements for emergency operation depend to a large extent upon the service supplied and the auxiliary drives and arrangements. For a price any degree of standby service can be provided but is seldom considered necessary beyond the provisions mentioned.

SECTION 5E

General requirements of speed and power advisable for combustion control. Many regulators operate faster than this but 45 sec. from one extreme to the other is several times faster than the boiler or auxiliaries can follow the change. Torque or thrust requirements for each machine should be obtained from the respective manufacturers and included in the specifications.

SECTION 5F

Some machines cannot be damaged if the control is moved while the machine is idle but with others, especially some types of mechanical speed changers, this possibility should not be overlooked by the designing engineer. Often this can be taken care of easier and cheaper on the machine than it can be on the control.

preventing this shall be positive and operative under all forms of automatic and remote control. Necessary electrical contacts in connection with the motor starters or switches will be provided by the Purchaser.

SECTION 5G
Markings, identifications and shipping instructions which must be complied with in conformity with the purchasing procedure of the company.

5G. SHIPMENT. Each instrument and separate part shall be suitably tagged, identified and marked: **"Specification No. 1001a."** Upon shipment, the manifest and two copies of the invoice shall be mailed to the purchaser without delay. The latter shall show both the Purchaser's and Contractor's order numbers and an itemized list of parts in each box or package.

SECTION 5H
While the usual control can generally be installed by a competent organization without assistance, it is well to have the erection supervised, or at least checked and adjusted by a manufacturer's representative.

5H. INSTALLATION AND SUPERVISION. Control equipment will be installed by the Purchaser, but installation is not intended to include cutting holes, drilling, tapping and assembly which can be done in the shop. The installation will be made in strict compliance with the Contractor's instructions. These shall be sufficiently detailed so that they can be followed by a competent mechanic and be available and complete on or before shipment. The services of an experienced service representative to supervise the installation, check the controls before they are placed in service, instruct the operators and/or make final adjustments as determined later shall be quoted on a per diem basis, plus living and traveling expenses. The Purchaser will give the Contractor ample notice when the services of this representative are required.

SECTION 5J
Details and measurements necessary for completion of the control should be supplied by or through the Engineer and not through a third party or manufacturer.

5J. VERIFICATION OF MEASUREMENTS. Where exact dimensions are necessary or the design depends on other machines, the Contractor shall verify them with the Engineer before proceeding. The Engineer will reply promptly and if the data is not available, will make such arrangements as necessary with the Contractor to avoid delay in design and construction. If these requirements are not complied with, the Contractor shall assume full responsibility for fit and performance with no allowance made for incorrect or incomplete data.

SECTION 5K
Preparation of the arrangement and layout drawings is part of the Engineer's job.

5K. SHOP AND INSTALLATION DRAWINGS. After the contract is signed, the Engineer will supply additional details or data as needed promptly and the Contractor shall then submit, without delay, two copies of all outline prints, piping and wiring diagrams needed by the Engineer to complete the installation drawings and layout. The Contractor shall cooperate with, and render reasonable assistance to the Engineer in connection with the arrangement and layout drawings.

SECTION 5L
While the control may be simple or so complicated that it is beyond the ability of the average mechanic or electrician to repair or adjust, instructions should be available so that minor repair or adjustments can be made without delay and so that the operators can better understand the equipment with which they work.

5L. OPERATING INSTRUCTIONS. The Contractor shall supply on or before shipment, two preliminary sets of instructions for the operation and adjustment of the control. These shall contain such illustrations of equipment and simplified diagrams as needed to make the instructions clear and shall be in addition to the instructions and drawings necessary for installation. Should the characteristics of the plant be different from those anticipated or should changes be made in the control, these instructions shall be revised not later than two months after the plant has been placed in regular operation, and, two additional copies provided for permanent use by the operating department. These final sets shall give complete instructions for the proper operation, adjustment and maintenance of the control.

SECTION 5M
Standard practice with machinery of all kinds. In some cases changes may be advisable to comply with specific requirements.

5M. PAINTING AND PROTECTION. All parts of the equipment shall be cleaned of scale, rust, grease and foreign matter with interior surfaces given at least one coat of shop paint. Unfinished exterior surfaces not mentioned elsewhere shall be given at least one coat of flat filler, suitable as a base for either a paint or enamel, well rubbed in and applied in ample quantity to give a smooth even surface requiring no further attention before being painted. Machined surfaces shall be coated with a suitable, easily removed, anti-rust compound before shipment.

SECTION 5N
Special tools are ordinarily supplied with machinery of all kinds.

5N. TOOLS. A complete set of new, good quality, special tools required to adjust and dismantle the entire equipment shall be furnished by the Contractor.

SECTION 5P
Standards of manufacture to be complied with.

Definition of special terms, or expressions, which have not yet been fully standardized and necessary to avoid misunderstandings.

Provision for acceptance tests. Formal acceptance tests of combustion control are seldom made for the performane of the control is quite evident in everyday operation and tests involve considerable expense and disturbance. Where they are necessary modification of the standard test procedure can be made to give the necessary information at less expense than a complete test. The complexity of the control problem in a modern plant is such that the preliminary adjustment should always be made by a specialist and no test should be considered, or performance judged until this has been done.

The A. A. A. has established and maintains a national system of commercial arbitration tribunals in some 1600 cities for the voluntary arbitration of civil and commercal controversies.

5P. STANDARDS AND TESTS. Where applicable, all electrical equipment shall de designed and shop connections made in accordance with the latest standards of the American Institute of Electrical Engineers and the American Standards Association, materials with the latest specifications of the American Society for Testing Materials, and piping with the latest American Standards Association Code for Power Piping. Expressions and terms shall be interpreted in accordance with the commentary on pages 432-33 of the July 1939 issue of Power Plant Engineering.

Acceptance tests that may be necessary or advisable in the opinion of either party will be conducted by, and at the expense of, the Purchaser: in accordance with the Power Test Codes of the American Society of Mechanical Engineers, complete, or modified as agreeable to both parties; and, only after the installation has been checked, adjustments made and the operators instructed in handling the controls, by the Contractor's representative on a per diem and expense basis as provided for elsewhere. The Contractor shall be notified of these tests at least 15 da. in advance in case he desires to have a representative present. The Purchaser will assume no expense involved with the representative in this connection as an observer but will cooperate with him, facilitate further adjustments of the control and supply copies of the test data. Subsequent tests or services of the Contractor's representative for change or adjustment, made necessary by the failure of the equipment to meet guarantees or specifications, shall be at the expense of the Contractor. Operating expenses, changes in arrangement of equipment or connections, and repairs in the boiler or setting necessary to reduce air leakage to an acceptable value shall not be considered as test expense and will

be paid for in all cases by the Purchaser. Any controversy or claim arising out of or relating to the contract shall be settled by arbitration in accordance with the latest rules of the American Arbitration Association.

5R. PATENTS. The Contractor is to pay all royalties and license fees; defend at his own expense all suits or claims for infringement of patents or copyrights; and save the Purchaser from loss due to these causes on all equipment supplied by him with the exception of the additional parts definitely called for by manufacturer's or trade names in these specifications. The Purchaser will cooperate fully with the Contractor in the defense of any such suit or action. Should the Contractor not wish to defend the suit, or if the equipment, or any part, is held to constitute infringement and its use enjoined, the Contractor shall at his expense and option: procure for the Purchaser the right to continue using it; replace it with non-infringing equipment approved by the Engineer; modify it subject to the approval of the Engineer so that it becomes non-infringing; or, reclaim title to the control and refund the purchase price.

SECTION 5R

Protection against patent infringement suits is commonly provided in machinery contracts and many companies have a standard form which they use. The one given is thought to be particularly applicable to combustion control which involves a large number of separate parts and combinations. In case of difficulty it provides for a number of possible solutions so as to give the minimum bother and expense to both parties.

ALTERNATE SECTIONS.

The following sections in italics are intended to cover fuel firing methods and equipment arrangements different from those used in the assumed plant as shown by Figs. 7 and 8, and these sections can be substituted as needed for corresponding sections printed in italics on the preceding pages. For simplicity the alternate sections are confined largely to data needed on the equipment with minimum reference to the control arrangement and intended method of operation. When used, these limited references were included to illustrate how different problems can be handled and should not be interpreted as standard practice. Both control and operating arrangements are extremely important from the standpoint of automatic combustion control. They should be known to the engineer and included in the specifications as required for a given plant.

In general the same provision can be made in all types of plants for such conditions as: operation with some of the burners out of service; starting auxiliaries from the panel or from some other point; panel arrangement; electrical and mechanical interlocks; etc. The practicability or necessity of doing these things depends upon the details of the equipment involved and is a problem of the plant designer. It should be kept in mind that the sections printed in italics on this and other pages are not intended as a standard form or arrangement but simply as an illustration of the type of data needed in a given case. As such they cover only the more common and not all types, combinations and arrangements of equipment and operating procedure. Neither are the combinations used in a given section inflexible for the subdivisions of each section can be changed and transposed to give the desired results. The question of control valves for oil, gas and steam require particular attention. These valves are of vital importance to the performance of the control but unfortunately all valve designs are not well adapted for use with all automatic combustion control systems. Inasmuch as the selection of one influences the selection of the other, it is necessary that those specifying equipment be thoroughly familiar with both pieces of equipment in order to insure the two working well together.

GAS FUEL

3C. FUEL. (Alt 2). *Under normal conditions a natural gas from the Atwater field purchased from the St. Croix Pipe Line Co. is burned. This gas has a specific gravity of 0.6 referred to air, a net heating value of 970 B.t.u. per cu. ft. at 60 deg. F. and 30 in. of Hg. and the following analysis in per cent by volume: CH_4, 93.5; N_2, 3.8; H_2, 1.9; CO, 0.5; CO_2, 0.2; O_2, 0.4. Fuel oil is used for standby service only and always under manual control.*

4G. FUEL SUPPLY TO FURNACE. (Alt. 2.) a. PLANT GAS SUPPLY. *Gas comes to the plant at a pressure of from 20 to 30 lb. ga. and passes through a meter and pressure reducing station which will be set to maintain constant pressure of 15 lb. in an 8 in. header which runs in front of both boilers. This pressure reducing and regulating valve is a 6 in. double ported Findlay, Fig. No. 17A, with low lift V-ports, a Type D pressure pilot and a Fig. 172 remote control loading pilot.*

b. BURNERS. *Eight Wadkin, Type 7S, 23 in. Combination oil and gas burners are installed, four on each boiler. Each burner has an adjustable air register as well as a Safeway combined interlocking gas and pilot valve to provide the operator with means to equalize gas and secondary air between burners or to shut off any burner independent of the others. With a gas pressure of 10 lb. ga. at the burner inlet and a secondary air pressure of 0.5 in. w.g., the maximum capacity of each burner is about 31,500,000 B.t.u. per hr. corresponding to about 20,800 cu. ft. per hr. measured at the actual conditions of 10 lb. ga. pressure and 100 deg. F., or 32,500 c.f.h. at standard conditions of 30 in. of mercury and 60 deg. F. The safe turndown is well over 4 to 1.*

c. GAS CONTROL. *Gas flows from the 8 in. header to each boiler through a 6 in. line to a manifold supplying the four burners in parallel. The total gas flow to each boiler is to be controlled automatically by a single valve in this 6 in. line. The control valves, one for each boiler, are to be supplied by the Contractor as part of the combustion control and should be designed so as to give accurate regulation for a range of from 25,000 to 130,000 c.f.h. measured at standard conditions of 30 in. of mercury and 60 deg. F. A 4 in. double ported Findlay No. 81 valve with Formized type ports has suitable characteristics for this service. With a 1½ in. valve lift, or about 85 per cent of the full travel, an inlet pressure of 13.5 lb. ga. and a pressure differential of 3.5 lb., the maximum caapcity of this valve is 130,000 c.f. measured at standard conditions. At 15 lb. inlet pressure and 13 lb. differential with a ¼ in. valve lift, the capacity is 24,600 c.f.h. measured at standard conditions.*

The above valve is built for either diaphragm or lever operation If, however, the Contractor wishes, he may use, subject to approval by the Engineer, a butterfly type or any other valve with suitable characteristics. The 6 in. line to each boiler is flanged ahead of the control valve for a standard Howson orifice to measure the gas flow to each boiler. The pipe at this point is 6.065 in. I.D. and the orifice 4.43 in. in diameter with the upstream tap 6 in. and the downstream tap 2½ in. from the orifice face. Allowance must be made for a permanent pressure drop of about 1 lb. across this orifice at maximum load.

Flow conditions as given are set by the maximum and minimum requirements with all four burners in operation as will be normally used under automatic control. All control valves have bypasses for emergency or low load operation and a Stanley No. 18A spring loaded relief valve, set at 20 lb. ga., and located on the downstream side of the pressure reducing valve, protects the plant header, burners and related equipment against excessive gas pressures.

OIL FIRING

Steam and mechanical, or pressure, atomizing burners are the two types most commonly used for firing large boilers. A more recent type is the steam-mechanical atomizing type where mechanical atomization is used at high loads and steam atomization at lower loads.

While some of the following sections have the pumps, burners and fuel control in specific combinations which may not agree with the combination used in a given plant, specification needs can be met by selecting and combining the subsections as required. For simplicity both constant speed and variable speed oil pumps are used in section 4Ga, Alt. 3. When only one type of pump is used, obviously the need can be met by omitting the reference to the second type and revising the data accordingly. Similarly specification requirements of a steam-mechanical atomization plant can be met by combining portions of Section 4Gc, Alt. 3, 4 or 5 as needed.

In principle, mechanical atomization is used at high ratings with the oil regulated by a control valve in the supply line. At lower ratings a differential regulator can be used to cut in and maintain a definite relation between the atomizing steam and the oil pressure. The arrangement to be used must be clearly outlined in the specifications.

3C. FUEL (Alt. 3). *Under normal conditions a No. 6 Midcontinent blended fuel oil supplied by the Clair Petroleum Products Co. will be used. This oil has an A.P.I. gravity of 18.5, a heating value of 18,000 B.t.u. per lb., weighs 7.8 lb .per gal. and at 185 deg F., the temperature at the burner, a viscosity of about 180 S.S.U. This oil runs about 1.05 per cent water and B.S. and a typical ultimate analysis used for gas calculations is in per cent: carbon, 81.5; hydrogen, 10.0; oxygen plus nitrogen, 6.9; sulphur, 0.55.*

MECHANICAL ATOMIZATION
Without Return

4G. FUEL SUPPLY TO FURNACE. (Alt. 3). a. OIL SUPPLY. *Oil is pumped from the storage tank by a No. 6 Kelly Twin Combination fuel oil set consisting of two pumps, each with a maximum capacity of 35 g.p.m. One is a 6 by 4 by 6 in. Kelly horizontal duplex steam driven pump, with a Master Fig. 16 pressure controller or pump governor, arranged for variable speed operation on 125 lb. saturated steam so as to maintain a constant pressure of 200 lb. ga. oil pressure at the fuel control valve to the burner. The second pump is a Kelly No. 18 rotary pump, driven by a 7.5 hp. Phoenix 440 v., 3 ph., 60 cycle induction motor arranged for starting and stopping from a hand operated safety switch mounted near the pump. The pressure of 200 lb. at the control valve is maintained constant by a spring loaded relief valve by-passing the excess oil to the pump suction. Oil temperature is held at 185 deg. F. so as to give an oil viscosity of 180 S.S.U. at the burners, by means of a Thomas Cat. No. 172 temperature controller which regulates the steam supply to two Kelly Size 192 oil heaters.*

b. BURNERS. *Each boiler has four Hatton Multiplex 16½ in. pressure atomizing burners each with a maximum capacity of 2050 lb. or 263 gal. per hr. of oil with a pressure of 190 lb. ga. at the burner. The capacity range is about 1½ to 1, giving a minimum capacity of about 1650 lb. of oil per hr. with the required pressure at the burner estimated at about 90 lb. ga. All atomizers on each boiler are in parallel and will be cut in or out of service manually by the fireman as required to carry the steam load. The control should be capable of operating within practical steaming limits of the boiler with two or more atomizers in operation and shall incorporate interlocks, or other means of limiting the draft to the fuel capacity of the atomizers in operation. Manually operated valves and air registers are provided to equalize oil and air flow between the burners, and by-passes around the control valve allow manual operation under emergency or light load conditions.*

c. OIL CONTROL. *The oil flow to each boiler is controlled automatically by a single valve in a 1½ in. line. The two valves required shall be supplied by the Contractor as part of the combustion control and shall give good regulation over a range of from 250 to 1100 g.p.h. Valve size and characteristics must conform to the needs of the burners and oil system, so as to give a boiler output approximately proportional to the valve lift, or, so that at least 50 per cent of the valve travel is utilized over the extreme expected load range of the boiler under automatic control. Suitable characteristics are given by a ¾ in. single V ported Findlay No. 217 with a maximum valve travel of ½ in. The capacity of this valve with a pressure differential of 5 lb. and a valve lift of $\frac{7}{16}$ in. is 1100 g.p.h. A Huntley Style A, Size 2 valve with adjustable rectangular parts also has desirable characteristics.*

MECHANICAL ATOMIZATION WITH RETURN LINE CONTROL

4G. FUEL SUPPLY TO FURNACE (Alt. 4), a and b. OIL SUPPLY AND BURNERS. Give the data for pumps and burners as indicated by corresponding subsections of Section 4G (Alt. 3) and add the details of the control as required. The constant differential control mentioned below is not always used. Whether it is or not used is important from the combustion control standpoint because it simplifies the problem by widening the range of operation possible with a single control valve and changes the control requirements to the pressure characteristics mentioned. Sometimes the same effect is obtained and the return of hot oil to the pump suction is eliminated by using a small constant speed auxiliary oil pump at each boiler.

c. CONTROL. *Oil is supplied to each boiler through a 1½ in. line and the return from each boiler to the pump suction is through a single line of the same size. Each boiler has a Penny differential control acting independently of the combustion control to maintain a constant differential of 40 lb. across the burner tip, regardless of the number of burners in operation. The control valve is located in the return line. It is closed when the burners are operating at maximum capacity and is opened as the capacity or boiler load decreases. Due to the action of the differential control the relation between the quantity of oil pumped and the return pressure is nearly a straight line function. The Contractors shall supply for each boiler as part of the combustion control, return line control valve with suitable characteristics for this service.* (Add flow and pressure data needed for valve selection to fit conditions as illustrated in Sect. 4G, Alt. 3).

STEAM ATOMIZATION

4G. FUEL SUPPLY TO FURNACE. (Alt. 5). (For steam atomizing burners, give the data for pumps, burners and oil control as indicated by Section 4G (Alt. 3) and add the following:

d. STEAM CONTROL. *Steam required for each burner for atomization is approximately 400 lb. per hr. at the maximum capacity of 2050 lb. of oil per hr. and about 175 lb. per hr. of steam at the minimum burner capacity. Steam pressure requirements at the burner are approximately 125 and 30 lb. ga. respectively under these two conditions. The control valves, one for each boiler, shall be furnished by the Contractor for automatic control in conjunction with the oil valve. The two may be separate or arranged in duplex form similar to Mohawk Duplex Valve No. 16. The valve shall be designed with regard to the characteristics of the oil control valve so as to give good steam economy and burner efficiency at all loads. Means shall also be provided so that the relative positions between the two valves can be changed manually so as to better match their respective characteristics. Steam for atomization is supplied at 150 lb. ga., 375 deg. F. through a single 2 in. steam line on each boiler. This steam is taken from the saturated steam header on the boiler through a Vance No. 61 pressure reducing valve.*

STOKERS

4G. FUEL SUPPLY TO FURNACE. (Alt. 6). a. STOKERS. *Each boiler is fired by a Mason Super Special No. 2 spreader type stoker with a fuel burning capacity of 9500 lb. per hr. when supplied with 2 in. of draft in the stoker windbox. Each stoker has 20 in. diam. rotors and four 4 by 13 ft. sections of manually operated dumping grates, giving a total grate area of 208 sq. ft. per furnace. Each front corner of each furnace has a steam jet made by the Higby Foundry Co., 4729 E. Water St., Chicago, Ill. The steam jets will be operated manually by the fireman as required.*

b. DRIVES AND CONTROL. *The rotating element of each of the four sections is driven at 500 r.p.m., through V-belts and a Sampson Style 16 speed changer, by a dual drive. At one end of each rotor shaft is a Phoenix 3 hp., Type CX 1750 r.p.m., 440 v., 3 ph., 60 cycle constant speed motor with a Savage Cat No. 1857 starter mounted near the stoker. At the other end is a Johnson Type XX, 3 hp. turbine with a constant speed governor.*

c. FUEL CONTROL. *A crank at the end of the main shaft drives a reciprocating feeder mounted in the hopper above the rotor. The length of the feeder stroke is controlled by the standard Mason ratchet arrangement with a sliding wedge, the position of which is to be contolled automatically. The four wedges on a single boiler may be controlled from one regulator or operating member if desired. Details of the ratchet and wedge are shown as a detail of Dwg. .... traced from the Mason Dwg. No. 1846D. (This sketch is not reproduced here.)*

CHAIN GRATE STOKER—MECHANICAL SPEED CHANGER

4G. FUEL SUPPLY TO FURNACE. (Alt. 7). a. STOKERS. *Each boiler is fired by a 11 ft. 6 in. by 22 ft. Simplex Model 17, six zone chain grate stoker with 253 sq. ft. of grate area and*

a maximum fuel burning capacity of 9500 lb. of coal per hr. with 2.5 in. w.g. draft available in the stoker windbox. Each is provided with a manually adjusted feed gate for controlling the thickness of the fuel bed. The air or forced draft pressure distribution between zones is controlled by manually operated dampers.

b. DRIVES. *Each stoker is driven by a Phoenix 3 hp., 1150 r.p.m. Type K, 440 v., 3 ph., 60 cycle motor through gears and a Francis No. 17 mechanical speed changer. This speed changer, which is on the motor side of the gears, has a range of 11 to 1. This will operate the stoker shaft at speeds of from 1 to 4 min. per rev. The gears are not provided with means of changing the gear ratio.*

c. CONTROL. *Control of stoker is to be accomplished automatically through a lever on the speed changer. This lever is 18 in. long, swings through an arc of 20 deg. in a horizontal plane above the machine and requires an operating torque of 275 ft. lb. The operating force may be applied to the lever at any distance from 12 to 18 in. from the pivoted end but the construction prohibits closer attachment. The motor and speed changer are mounted on top of the stoker worm gear. The operating member may be mounted on a column directly to one side of, and about 18 in. from, the lever or may be mounted on the floor and the force transmitted through a suitable lever and bell crank arrangement.*

d. METERING CONNECTION. *The gears and speed changer are totally enclosed but should a tachometer be needed with the control to measure stoker speed it may be driven from the 2 in. shaft of the worm gear which extends about 6 in. outside of the gear housing. This shaft has a 3/8 in. keyway, 1/4 in. deep and the speed range is from 200 to 800 r.p.m. Details of the drive and shaft are shown on the manufacturer's drawing No. 430-3-6.*

UNDERFEED STOKER—VARIABLE SPEED MOTOR DRIVE

4G. FUEL SUPPLY TO FURNACE. (Alt. 8). a. STOKER. *Each boiler is fired by a Union, multiple retort Type A3 stoker with 160 sq. ft. of projected grate area, and a maximum fuel burning capacity of 9500 lb. of coal per hour with a draft of 5 in. w.g. in the stoker windbox. The stokers are provided with manual adjustment for control of fuel bed and manually operated dampers in the windbox for guiding the air and controlling the pressure at the overfire section.*

b. DRIVE. *Each of the two stokers is driven by a Phoenix 5 hp., Type AY, 440 v., 3 ph., 60 cycle brush shifting motor with a speed range of from 600 to 2400 r.p.m. The motor is equipped with a Savage Cat. No. 1731 starter arranged for manual operation from a station near the stoker. The motor drives the stoker crank shaft through a gear box at a speed of from 1/4 to 1 r.p.m. and is set with the shaft parallel to the stoker shaft. The gear box is equipped with a high speed, low speed, and neutral position. The control should be designed for operation with the power box in low speed. Necessary change in gear box position will be made by the operator.*

c. CONTROL. *Speed control of the motor is to be effected automatically by moving the brush yoke on the motor frame. The shaft by which this change is made requires a full 180 deg. of rotation and is now equipped with the short lever supplied as standard equipment with the motor and suitable only for hand control. It is located on the front end of the motor and moves in a vertical plane at right angles to the motor shaft. For automatic operation this lever may be replaced by a sprocket or by a pilot motor as most convenient for the Contractor. Gears or pilot motor and levers as needed shall be supplied by the Purchaser insofar as they can be purchased from the motor manufacturer as standard parts. The pilot motor normally supplied by the motor manufacturer is a Phoenix, Type A, a.c. split field series motor operated from either a 75 or 115v. tap of a special transformer.*

OTHER STOKER DRIVES

Many different stoker drives are used. The data in Section 4Gc (Alt. 8) is typical of all types of variable speed motors —i.e., data on motor, starter and method of operation. Section 4Gc (Alt. 7) is typical of speed changers. Two other common drives are:

STOKERS—HYDRAULIC DRIVE

4G. FUEL SUPPLY TO FURNACE (Alt. 9). Use Sections 2 and c of 4G (Alts. 7 and 8) as needed.

b. DRIVE. *Each of the two stokers is driven by a Beloit, Size 3, hydraulic transmission with a speed range of 15 to 1. The oil supply pump for the drive is driven by a Phoenix 5 hp., 1150 r.p.m., 440 v., 3 ph., 60 cycle Type AR motor with a Phoenix Cat. No. 1830 starter mounted near the stoker.*

d. CONTROL. *Speed of the stoker is to be effected automatically by moving a rack which changes the length of the oil pump stroke. This rack has a full travel of 3 in. It is set horizontally above the main drive at right angles to the motor shaft and has a handwheel for manual control. Space is available at the end of the unit for mounting the regulator, necessary levers and supports. Details of the drive construction are shown on the Beloit Foundry Co.'s drawing No. 347X.*

e. METERING CONNECTION. (This is a positive drive and the position of the rack is in itself a measure of the stoker speed. For control manufacturers who prefer to use a tachometer, give the data similar to Section 4Gc, Alt 7.)

STOKERS—STEAM ENGINES OR TURBINES

4G. FUEL SUPPLY TO FURNACE (Alt. 10). Use sections a and c of Section 4G (Alts. 7 and 8) as needed.

b. DRIVE AND CONTROL. *Each stoker is belted to an England Vertical Type T, 3¼ by 4 in., 4 hp. steam engine supplied with steam by a 1 in. line about 50 ft. long with three right angle bends from the 125 lb. ga. saturaed header. The steam connection on the engine is ¾ in. with the frame machined and drilled in accordance with the American Standards A.S.A. B16a-1933 for 125 lb. cast iron pipe flanges and flanged fittings. At its maximum speed of 500 r.p.m., the engine drives the stoker shaft at 1 r.p.m. The maximum steam consumption of the engine is 256 lb. per hr. The Contractor is to supply as part of the combustion control, the steam valve or governor required to automatically control the speed. To pull its maximum load 118 lb. gage steam pressure is required in the steam chest and the steam valve must be of sufficient size so that the maximum flow can be obtained with a pressure differential of not more than 5 lb. ga. The valve and governor used must provide for the variable torque requirements of the stoker and also prevent stalling of the engine at low loads. (Add details of gear box used.)*

PULVERIZED COAL

Pulverized coal is widely used in plants of all sizes. The original bin or central system, in which the coal is pulverized and stored in bins to be fired as needed, has been largely superseded in the newer plants by the unit or direct fired system, in which the coal is pulverized and blown directly into the furnace without utilizing an intermediate storage.

Several types of mills are in use and to a certain extent the coal feed and control is determined by the mill selected. Some mills, however, may be equipped with one of several feeders and the feeders in turn may be driven and controlled in different ways so that it is necessary to be specific regarding the mill, the feeder, and both the raw and pulverized coal feed. In many cases the raw coal feeder is controlled independently of the combustion control which must then control the pulverized coal feed to the furnace by a damper in the primary air duct or in the duct carrying the coal-air mixture. One such arrangement is covered by Sec. 4Ge, Alt. 11. Fuel metering can often be made by measuring the primary air flow and assuming that a given quantity of air carries a given quantity of coal dust.

When the raw coal feeder is directly under the combustion control, a metered indication may be possible as in Sec. 4Gc and d, Alt. 1, or it may be necessary to resort to pure positioning as in Sec. 4Ge, Alt. 13. To increase the flexibility, for operating convenience, or to eliminate the problem of time lag brought about by the coal storage capacity of the mill, both feeder and damper control is sometimes resorted to as in Sec. 4Ge, Alt. 14. The examples which follow are only a few of the arrangements used and when included in specifications should be amplified by the additional details covered by the complete Sec. 4G, Alt. 1.

PULVERIZED COAL—CENTRAL OR BIN SYSTEM

4G. FUEL SUPPLY TO FURNACE (Alt. 11). Give data on pulverizers, feeders and control burners, metering connection and primary as in Sections 4Ga to d and (Alt. 1) as a matter of general information and add a brief description of the arrangement for getting pulverized coal from pulverizers to bunkers such as: *Pulverized coal from the cyclones on the outlet side of the pulverizers is pumped to the pulverized coal bunkers above the boiler by one of two Howson screw type coal pumps.*

b. BURNERS. *Same data as Alt. 1.*

4Gc. FEEDERS AND CONTROL (Alt. 12). *Raw coal is supplied to each mill through a Wagner Model CC, Size 2 feeder driven by a Phoenix, Type KC, 1 hp., 110 v., 3 ph., 60 cycle constant speed motor with a Phoenix Style 832 starter. This feeder is operated intermittently, and independently of the combustion control by a Wagner Type A control. The pulverized coal feed to the boiler is to be regulated by the automaitc combustion control through a damper in the 10 in. diam. duct leading from the mill to the burner. The duct is vertical and the damper is 4 ft. above the floor. Details of the damper, with a cut-a-way section to limit the minimum coal flow, is shown by the drawing No. .. (Not reproduced). The primary air flow is metered in a Venturi section and the calculated pressure differentials are: full load, 2.2 in. w.g.; half load, 0.6 in. w.g.; quarter load, 0.2 in. w.g.*

4Gc. FEEDERS AND CONTROL (Alt. 13). *Each pulverizer has a Grayton Size 3, Star feeder driven by V-belts from the pulverizer shaft. The raw coal feed to the mill is to be controlled automatically, through the standard Grayton pawl and ratchet arrangement in which the movement of the feeder rotor for each revolution of the driving crank is determined by positioning a lever. Details and dimensions are shown in the manufacturer's Bulletin P 17, page 36 and by Drawing No. 1875 revised 4-6-37.*

4Gc. FEEDERS AND CONTROL (Alt. 14). *The fuel feed is to be controlled automatically by simultaneous adjustment of the raw coal feeder and the air flow to the primary air fan. The raw coal feeder is a Jenkins Size 6, driven by a Phoenix Type K C, 1 hp., 1150 r.p.m., 110 v., 3 ph., 60 cycle constant speed motor and equipped with a two speed gear box which gives a table speed of 18 or 28 r.p.m. It is expected that the high speed will be used in and be adequate for normal operation, and when required the speed change will be made manually by the operator. The raw coal feed is controlled by positioning a knife or plow on the rotating table by means of a lever as shown by the detail drawing No. .. (Not reproduced here). Details of the damper in the 12 in. diam. to the primary air duct are shown on the same drawing.*

FORCED AND INDUCED DRAFT FANS

A large variety of fan drives are also used. Data on the fan itself should always be included in the specifications as shown by Sections 4Ha and 4Ja, Alt. 1. With a constant speed drive and dampers, only the general features of the drive are necessary but all details of the dampers should be included as in the latter part of Section 4Jc, Alt. 1 which also covers a combination of multispeed motors and dampers. For inlet vane control see Sec. 4Hc, Alt., 1; for typical variable speed motor drive see Sec. 4Gc, Alt. 1 and 8; for mechanical speed changer see Sec. 4Gc, Alt. 7; for a steam engine drive see Sec. 4Gc, Alt. 9. Steam turbine drive data is similar to that for engines and can be worded as follows for either stoker or fan drives:

STEAM TURBINE DRIVE

4H and 4J, Alt. 2. a. Fans. Use same type of data as in Section 4Hc and 4Jc of Alt. 1 and

b. DRIVES AND CONTROL. *Each fan is driven by a Justin Type E mechanical drive turbine geared to drive the fan (or the stoker shaft) at a maximum speed of 1100 r.p.m. The turbine is supplied with 450 lb. ga., 550 deg. F. steam and exhausts at 5 lb. ga. At its rated capacity of 68 hp. and 5000 r.p.m. an inlet ring pressure of 407 lb. is needed and the steam consumption is 2350 lb. per hr. This steam is supplied through a 1½ in. line about 50 ft. long and with two right angle bends. The steam inlet to the turbine is 1 in. with the casting machined and drilled in accordance with American Standards B 16e-1939.*

c. CONTROL. *The speed control valve or governor is to be supplied by the Contractor as part of the combustion control and shall be large enough so that the pressure differential at maximum flow does not exceed 25 lb. This valve or governor shall be designed or arranged to provide for varying torque requirements under different operating conditions. A hand operated by-pass valve is provided for emergency or low load operation.* (If dampers are used add data, also method of operation and the control requirements desired.)

HYDRAULIC COUPLING—OIL PUMP TYPE

4G and 4J (Alt. 3). Use data on fans as in Sec. 4Ga or 4Ja.

b. DRIVES. *Each fan is driven through a hydraulic coupling by a Phoenix Type AH, 440 v., 3 ph., 60 cycle, 60 hp., 1150 r.p.m. induction motor equipped with a Phoenix Style 1428 across-the-line starter located near the fan. The hydraulic couplings are Bullock Type C, No. 15½ with a speed range of 5 to 1, the maximum fan speed being about 1100 r.p.m. The size of the coupling oil pump used is sufficient to give full range of speed from one extreme to the other in about 1½ min.*

c. CONTROL AND DAMPERS. *The flow of gas (or air) is controlled automatically through fan speed by changing the quantity of oil in the coupling. Either the reversible pump, or continuously running pump with regulating valves, may be used as more convenient to the Contractor, provided the desired regulation can be obtained with the combination of coupling and control proposed. The coupling contract includes a Monon Type R, ¾ hp., 440 v., 3 ph., 1750 r.p.m. motor suitable for either continuous or reversing operation, necessary oil piping but no motor starter.*

The Contractor shall supply as part of the combustion control, parts and equipment required to give the elected method of speed control.

HYDRAULIC COUPLING—SCOOP TYPE

Section 4Jc. (Alt. 4). CONTROL AND DAMPERS. *The flow of gas is controlled through the fan speed by changing the quantity of oil in the coupling by means of an adjustable scoop tube. This scoop tube may be positioned in one of two ways as convenient for the Contractor: first, by means of a pilot motor; second, by means of a lever. The lever is 12 in. long and must move through an arc of about 58 deg. in a plane perpendicular to the coupling shaft. This 58 deg. arc may be located anywhere except in the bottom 120 deg. of the circle where the main shaft interferes. This shaft also prevents the use of a sprocket wheel of more than 3 in. diameter for use in connection with a pilot motor. The pilot motor must be mounted at or above the scoop tube shaft, which is 3½ in. vertically above the centerline of the driven shaft. Details of the arrangement are shown by the manufacturer's drawing No. 1632-44. Provisions to accommodate the control will be made by the Purchaser.*

NATURAL DRAFT

The specifications can be simpler than with forced draft but the arrangement can be the same. Sections 1 and 2 require no change except the omission of sections as needed. Section 3 requires little change in form beyond that necessary to make the descriptive material comply with the plant in question. Several parts of Section 4 will be automatically eliminated because the equipment is not used. Section 4G, Fuel Supply to Furnace, must be included with the data revised to comply with the operating conditions for which it was purchased. In place of Section 4J. Induced Draft Fans, substitute a description of the uptake damper, stack and breeching with the maximum draft available at the uptake damper. For a simple control, all of the parts marked ** should be omitted but for a more elaborate control, more care must be exercised so as to avoid omitting sections needed to clearly outline what the control is expected to accomplish. When forced draft is used without induced draft fans, the changes necessary in the specifications as written are quite apparent.

Wendell L. Willkie, who played the role of Paul Revere in the late controversy between the Utilities and the Administration, spoke at the dedication of the new Bryce E. Morrow plant of the Consumers Power Co. near Kalamazoo, Mich., on Nov. 8. Mr. Willkie, president of the Commonwealth & Southern Corp. and chairman of the board of the Consumers Power Co. shared the program with several Consumers executives: D. E. Karn, vice president and general manager; Frank G. Boyce, vice president and manager of the electric production and transmission department; and H. S. Richmond, district manager.

Bryce E. Morrow Plant

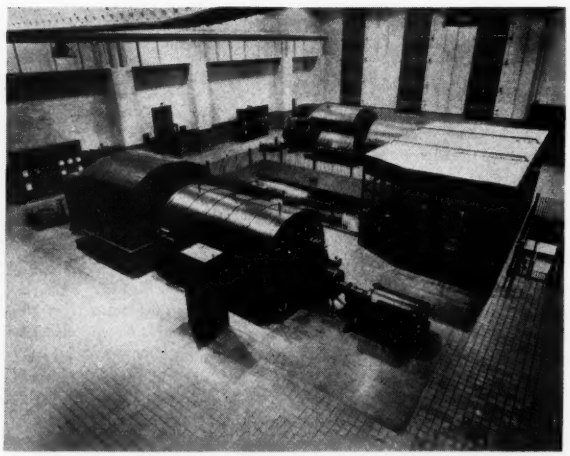
BRYCE E. MORROW Plant, dedicated on Nov. 8, is the second largest of the Consumers Power Co. plants and adds 70,000 kw. of capacity to the interconnected system which covers a major portion of southern Michigan. This capacity is in two General Electric 35,000 kw., 14,400 v., 3 ph., 60 cycle, 3600 r.p.m. hydrogen cooled units. Turbines are of the tandem compound, double flow type, with 21 stages each, operating with 800 lb., 850 deg. F. at the throttle and exhausting to Foster Wheeler 33,000 sq. ft. condensers. The plant is located east of Kalamazoo across the Kalamazoo River from Comstock. Condenser cooling water is taken from the river, a low dam having been constructed to give adequate storage.

Steam is supplied by two 400,000 lb. per hr. Foster Wheeler steam generating units with water walls, economizer, tubular type air heaters and bypass damper control of the superheat. Each unit is fired by two Hardinge conical ball mills each supplying two Peabody burners. Feeders and fans are located on the operating floor with the mills themselves encased in sound proof housings, on the lower level.

Each boiler has a Sirroco Type S. T. fly ash collector and one forced and one induced draft motor driven fans. Turbines are arranged for bleeding at five points, the first two being utilized for the evaporator, the last three for three closed heaters. A more detailed description of the station, with plan, cross section and flow drawings appeared on page 164 of the March, 1938, issue in an article by Geo. C. Daniels, chief mechanical engineer of The Commonwealth & Southern Corp.

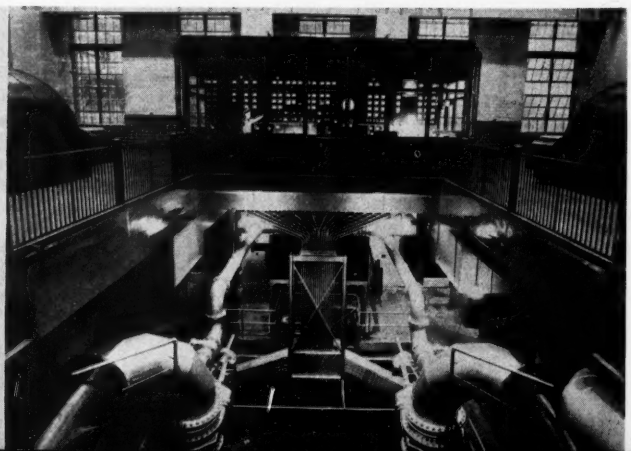
In normal operation the plant will consume about 200,000 t. of coal annually and a storage area with 165,000 t. capacity has been provided. Coal is stored and reclaimed by an 8 cu. yd. Sauerman drag scraper system. The storage area is semi-circular in shape and the Sauerman Crescent bucket operates back and forth between a headpost located at the track hopper and a self-propelled tail tower which travels on a 20-ft. ga. track laid around the curved edge of the area. The maximum capacity demanded of the scraper, either storing or reclaiming, is 200 t. per hr., the rated capacity of the 8 cu. yd. bucket when operating on a haul of 300 ft.

Coal will be piled to an average height of 25 ft. The



scraper operator, stationed in a control tower over the scraper hoist, operates the scraper by means of push buttons and levers. He also controls the movement of the tail tower by a reversing drum switch. A power cable supported by a catenary messenger cable is suspended on the radius between the headpost and the tail tower. From the track hopper coal is carried to the plant by a Bartlett & Snow conveying system.

Mr. Willkie, carrying on the fight for the preservation of America's free tradition and free enterprise, said: "This new power plant is a symbol of better standards of living for the people, a symbol of men at work, and wages creating a widening circle of employment—and more than a symbol, it is a living demonstration of the fruits of freedom in enterprise in the American way. . . . The three fundamentals, without which there cannot be real democracy, are the democratic process, civil liberties, and free enterprise." These three foundations of American democracy he compared to a tripod, in that if one is destroyed, all will collapse.



The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

INTRODUCING MR. MORRIS

When we launched the "Practical Engineer" last summer we did it with the intention of keeping it alive and vigorous. We felt that one man should be responsible for its contents at any one time but to keep it from growing stale or monotonous this responsibility should be changed frequently. I was given the job of launching it, of fashioning the first few issues out of material that was available and directing its course into channels of interest that would make it valuable and entertaining to practical men. Its success during the past six months has exceeded all my expectations and it is not without regret that I now relinquish the editorship to my staff associate, Richard Morris, but I realize more than anyone else the desirability of this change. I hope to be back with you again in a year but in the meantime Mr. Morris and next July Mr. Turner of our staff will be in charge and I assure you they will maintain your interest. The general informal character of the section will be preserved but each man in his turn will give to it the individuality that is peculiarly his and you will find that refreshing. It has been a pleasure for me to work with all of you who have been so helpful in making this section a success, so in saying au revoir, I want to thank you and, since this is the December number, wish you all a very Merry Christmas.

Andrew Kramer.

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A Section of Power Plant Engineering

TECHNICAL PUBLISHING COMPANY

53 WEST JACKSON BLVD., CHICAGO, ILL.

Mr. Knapp has been a subscription salesman for Power Plant Engineering for twenty odd years. During that time he has visited and re-visited thousands of plants and institutions and many of you along the Eastern seaboard know him personally. His close and continuous contact with engineers of all classes in plants of all sizes and types provide him with a unique and enviable knowledge of conditions and opportunities in the power plant industry, so we asked him to write this article. He has done a "swell" job and no matter what your status in the industry, whether you are a coal passer or the power superintendent of a great plant, you will find his discussion of the subject of interest and quite possibly of value. Ed.

So, You Want To Be An Engineer?

By H. A. KNAPP

DURING MANY YEARS OF TRAVEL among power plants of all sizes and classes, I have frequently heard older men attempt to dissuade younger men from entering the "profession," contending that the outlook was dismal. This attitude of older men is more or less characteristic in all trades and professions and whatever basis an individual may have for such an attitude, my own broad contact with the power industry leads me to quite opposite conclusions, indeed, in this short consideration of the subject I hope to show that the power plant industry is one of the largest and most diversified in the world and that it offers as much, if not more, opportunity than other modern industrial fields. Those holding opposite views probably do not comprehend the extent of its horizontal ramifications or fail to appreciate effective methods of advancing themselves; in some instances the attitude may be the result of accidental adverse experiences.

Stationary engineering has three fairly distinct divisions; utility, industrial and service. To a certain extent these three divisions present common characterstics but each one presents specialized aspects and opportunities which may attract a man to them. Originally, many young men followed their father's footsteps in choosing this as their life's work but their number appears to be decreasing, mainly because of changes in methods and partly because of the attitude on the part of the older men referred to above—the older engineer influencing his son unfavorably.

During the past two or three decades a considerable number of men have migrated from the marine field as the demand on the sea diminished. Generally, the marine man becomes a capable and desirable stationary engineer, having the advantage of a thorough training in both operating and repair work the latter usually with limited equipment, a good training in accuracy and cleanliness and, generally, a robust physical condition.

The marine service is the only one of the mobile branches of the industry which provides good men for the stationary field. There is some interchange between the land portable and stationary but these men, while generally efficient workers, seldom reach the top ranks. There is little migration from the locomotive to the stationary and still less from the automotive.

Many young men enter the power plant field because they feel incumbent to establish a connection upon completing a technical school or college course, some because of a preference for the work while others enter it merely because of a chance opportunity. Admitting the value of technical knowledge, it is not always true that technical training acquired previous to employment produces the best results. The technical graduate ostensibly must work down from a higher and more comprehensive status to a lower and more specialized one and he often fails to appreciate the essential object of his work, the economical production of light, heat and power. From a common sense viewpoint he is working backwards.

Older men frequently dissuade younger men from entering

This is not true of the practical man who forges ahead by absorbing knowledge adequate for the job at hand and who later acquires technical knowledge for the job to come. The practical man often envies the technical man and frequently is held back by an inferiority complex, but he should derive consolation and renewed determination from the fact that the technical graduate has acquired a great deal more knowledge than he actually needs for his job and frequently much more than he needs for the work which he may expect to perform in the future.

The bulk of power plant personnel, however, is recruited from the vast army of young untrained and inexperienced men who at some time or other make the connection simply because they need a job. These men usually fill positions in the lower brackets, often on the coal pile, and, while the percentage of those attaining advancement is small, yet this group produces some of the most valuable men in the business. They have the advantage of starting from scratch, lack erroneous preconceptions of the work and usually advance from job to job in a constructive rotation favorable to the attainment of substantial knowledge.

The Utility Field

The utility field is divided into two parts, the publicly owned plants and those privately owned. Opportunities in the former are somewhat limited, first by the relatively small size of the plants and secondly by the political angle. The capable top men, those qualified to take charge, are very much in demand regardless of political affiliations, but the average operating and maintenance engineer does not advance readily. Of course, it pays him to learn as much as he can so as to place him in a position to "cash in" if a better opportunity presents itself. Consulting engineers of lesser prestige find numerous clients in this field as the properties are seldom affiliated with other interests.

Contrasted with the situation in the publicly owned plant field, opportunities in the privately owned utility field are enormous. Strangely enough, so-called government competition has enhanced chances in operating companies because many of them now do the larger part of their construction work which was formerly let out to outside engineers and contractors. It is difficult, however, to devise a formula

You may even smell a potential job

for advancement in this field other than hard work, the proper use of personal ingenuity and mastering the knack of working in harmony with the entire organization. Men who possess these qualities are usually advanced almost automatically. There is little migration of employment from one company to another, particularly in the operating departments, but there is a fair amount of this in the construction and engineering departments. Long tenure of employment is an established condition. The young technical graduate has a distinct advantage in these companies because the work is more intricate and expansive and he is better trained to grasp it. In the designing and engineering departments he is practically indispensable. Despite this a surprisingly large number of men, originally non-technical, are in charge of large station operation and construction.

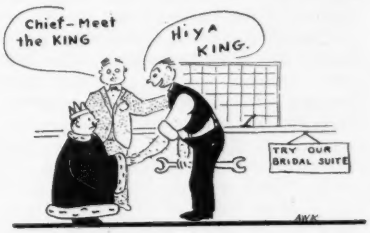
Opportunities in the Industrial Field

Records indicate that the tenure of employment in the industrial field is much shorter than in the utility field. This is attributable, mainly, to two factors, first uncertainty in the structure of organization due to fluctuation in production and secondly, the ever imminent contingency that industrial plants may change to the use of purchased power or steam, or both, which nullify or diminish the engineer's importance. For these reasons the industrial engineer should be continually on the alert for a new opening even if only as an emergency measure. Occasionally one betters himself in making a change but a vast army of engineers jump from job to job without advancement, losing considerable time and remuneration during idle periods. When diminished plant production knocks the engineer out of a job, there is not much he can do about it except look for another opening or await industrial recovery, utilizing his spare time to best advantage.

For those engineers, however, who are faced with impending discontinuance of all or part of their power house in favor of purchased power, there is, fortunately, a very favorable solution; let them gradually work themselves into other lines of endeavor which are affiliated with their job. First, they should learn as much as possible about the maintenance and operation of equipment outside the power plant proper but in some way associated, such as heating systems, piping, electrical equipment which are practically always present; sometimes such associated lines include automotive, portable and locomotive equipment. As much as possible should be learned about the upkeep of the production machinery and wherever possible about the production processes themselves. Most engineers have the advantage of having to work, periodically, in sections of the plant apart from the power house, particularly where steam and electric power are applied for process work, and have a unique opportunity for acquiring knowledge of many other phases of the business. Since the engineer's background includes some knowledge of steam, electric and usually machine shop work, he is particularly adapted to assimilate knowledge of production methods and the jump from chief engineer to assistant superintendent should be much more common than it actually is.

There is, however, a simple explanation for lack of this kind of advancement, one which is quite obvious if one has had personal contact with some of the "old timers" many of whom are by no means old in years.

When some agency induces the management to purchase power or steam or both, thereby shutting down all or part of the existing power plant, by far too many engineers assume a defeatist attitude, some actually quitting the job while others retrograde to lower positions, frequently becoming ordinary handy men. It is unnecessary to comment on the folly of such a course of action. In such cases the engineer should first make a thorough study of the power costs to make certain that the management is pursuing the proper course and to try to win back the plant if he finds that the move is wrong. If he is unable to do this, which usually is the case regardless of whether it is proper, he is foolish to neglect the big opportunity to master other phases of the business with which he is associated. More



The hotel engineer has close association with the patrons

often it is a blessing to some of these men to have the old time power plants discontinued as most of them are sordid places with sweat box temperatures and inadequate ventilation and with no provision for acoustic relief; they are unfit for human occupancy. It is a sad commentary on the state of progress in industry that thousands of such plants are in existence today. (Amen! Ed.)

Engineers in the industrial field who stay in power plant work permanently usually advance in their own companies due to their own ingenuity in effecting economies (provided that they are not too reticent to let the management know about it) or, in the absence of expansion by their own employer, through merely keeping their eyes open for bigger opportunities, many of which are of a supervising nature in which they have charge of more than one property. Again there is no set rule for learning of these openings except to have recourse to the five senses, particularly hearing and sight; you hear of a new job or you read about it; you may actually see a property in the course of construction, particularly the conspicuous smoke stack, and infer that there is an opening there. You learn of a dismissal, an advancement or a demise and naturally you infer that these circumstances create an opening. You may even smell a potential job such as a tannery, packing plant, paper mill or brewery, all of which emanate distinctive odors. If you are sauntering by a property and a brick falls on your head you may be benefited by sense of feeling. Taste does not play such a large part but you may partake of some particular palatable product and infer that the producer has demand for a good engineer. (N.B. The brewery field is overcrowded and distilleries do not permit their employeers to imbibe while working.)

If you do find a new opening it is of prime importance to determine the proper individuals to contact. It is generally best to aim high as it is usually more comfortable to work from the big fellow down than it is to work from the little fellow up, providing of course that these steps are necessary which they frequently are. The con-

sulting engineer is usually a good man to approch as his engineering prestige should carry weight with the management. In the absence or inavailability of such, try to contact some executive of the organization, preferably one who has a kinship of indirect friendship, nationality or fraternalism.

Classified advertisements in newspapers and periodicals are of doubtful value, mainly because of the large amount of competition encountered. It is also quite common that such advertisements, usually without the knowledge of the publisher, turn out to be "blind ads" used to obtain leads for sale of some other product such as a set of books, a course of study, an employment service or almost anything which might appeal to a dissatisfied person.

To summarize, the industrial field with its many opportunities within itself and the closely associated ones outside of itself offers the most numerous possibilities of the three.

The Service Field

The service field is the largest field of all if you wish to include all service properties which have engineering equipment of some sort, no matter how small. But since only the larger ones employ engineers, we shall deal with them solely. Many service plants are, of course, publicly owned, such as the vast number of municipal, state and government buildings, hospitals, penal institutions, homes and so forth. Most of these are subject to civil service requirements, thereby affording openings for the more intelligent engineers through conventional channels. Political factor is also present, to an extent generally in inverse ratio to the size of the controlling body, least in government and most in municipal. Yet after making a connection in this field, the engineer who performs his duties efficiently and evades political complications as much as possible, usually has a permanent position. But many of these men never acquire the knack of advancing themselves which really consists of personal efficiency, executive ability and political diplomacy, all three employed in the timely manner dictated by intuition.

Charitably or religiously endowed institutions such as hospitals and homes present a difficult problem for the engineer. Most of them are almost permanently on record as lacking funds. The engineer in charge often acquires a miserly frame of mind in relation to his subordinates and engages help which is generally low paid but usually partly compensated for by free living-in privileges. This condition attracts many floaters with resultant of large turnover of labor. These conditions do not, however, prevail in the larger and better financed institutions. The chief engineer who can show economical operation and ability to keep his department in good shape both from efficiency and sanitary standpoint, is very much in demand, usually at a good salary. Advancement into other branches of the organization is not so common as the latter is usually composed of medical men or technicians in lines remote from the engineer's work. His best chance is for a supervising job where more than one property is involved.

Hotels, large apartment houses, office buildings, large clubs, etc., really offer the most unrestricted chances for advancement in the entire service field. Engineers with views to the contrary usually lack coordinative ability or personality. The hotel engineer, for instance, has very close associations not only with the management and employees of other departments, but also with the patrons of the establishment. In this connection, engineering ability, of course, is essential but tactful diplomacy plus personality are of almost equal importance. These engineers have wonderful chances to advance to a supervising job or one in a managerial capacity. The same is true to a large extent in the office building field.

In department stores, theatres, museums and auditoriums the engineer does not have so much contact with the patronage. His chief duty is to supply conditions of comfort for them. The largest jobs are in the department stores which usually include supervision over warehouses and other properties. There are some very remunerative supervising positions in tht theatre field.

On the whole we may say that the service field require more of the human element.

Other Fields of Opportunity

There are numerous other outlets which do not come under these classifications. Many engineers go in for construction, erection, service, designing, estimating and sales work with manufacturers of power equipment; also test and research work for such units as fuel sales and electrical equipment organizations; there is also the large insurance business which employs power plant men as supervising engineers, inspectors and even special agents. There are many other openings too numerous to mention.

A Logical Conclusion

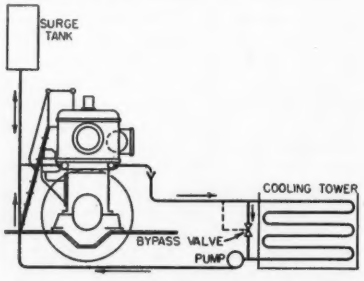
Partially or in their entirety power plant men are versed in the following: scientifically in mathematics, physics and chemistry; professionally in mechanical, electrical, chemical and structural engineering; practically in operation and maintenance of boilers, prime movers, electrical apparatus, internal combustion, refrigeration and their various auxiliaries as well as boilermaking, pipe fitting, heating and ventilation, air conditioning, insulation, welding, instruments, electrical maintenance and construction, millwrighting, machine shop, conveying machinery, plumbing, sprinkler systems and, dear reader, perhaps you can supply more.

Now does it seem logical that men educated and experienced in these many essentials should lack opportunity? Or do you think that it is probably or potentially or actually the biggest field of human endeavor which we have with us today? Answer the question yourself.

FOR THE DIESEL OPERATOR

Diesel Cooling Water

For best results cooling water from engine jackets should be held at a constant temperature. The quantity circulated should also be held within rather close limits in order to maintain the velocity in the jackets at a value which will give effective cooling. The simplest way to do this is by means of a thermostatically operated valve located in a bypass line from the cylinder discharge to the pump suction.



A constant water temperature leaving the cylinder can be obtained from a simple thermostatically controlled valve on the bypass line to the pump suction

This valve should be operated from a thermometer or thermostat in the line carrying the warm water from the cylinder, preferably in such a location as to obtain an average temperature reading.

In multicylinder engines it is advisable to have valves and individual thermometers from each cylinder so that the flows and temperatures can be equalized. While not absolutely necessary, it is good practice to have a balast tank floating on the discharge side of the pump. This provides a constant head on the cylinder at all times and gives an emergency supply to protect the engine in case of temporary failure of the circulation pump. Sight feeds on the discharge or overflow side of the cylinder also enable the operator to notice any sudden change in flow through the cylinder jackets.

Diesel Bearing Failures

Bearing failures account for approximately one-third of the total number of accidents to insured Diesel engines according to H. J. Vander Eb, assistant chief engineer of the turbine and engine division of The Hartford Steam Boiler Inspection & Insurance Co., in a recent

number of The Locomotive. In view of this large proportion, the causes of such failures should be of interest to owners and operators of engines.

Excessive bearing temperatures, produced either by high rubbing speed at the bearing surfaces or by the heat transmitted from the pistons to the lubricating oil, reduce the load-carrying abilty of bearing babbitt. The melting temperature of babbitt is only about 460 deg. F. and tests have shown that at 212 deg. F. the compressive strength of babbitt is about one-half what it is at normal room temperature of 70 deg. F.

Its strength is further reduced at temperatures higher than 212 deg. F. The temperature of the oil is used as an indication of the condition of the bearings, but the actual temperature of the bearing lining is frequently as much as 50 deg. F. higher than that of the oil leaving the bearing. From these considerations it should be clear that temperature plays a most important role in bearing life and that every possible precaution should be taken to keep the bearing temperatures within reasonable limits.

As the oil comes from the bearings the recommended limit for temperature is 130 deg. F. This is regarded by some engineers as being rather conservative, but the experience quoted above shows that there is ample justification for some conservatism.

Aside from the question of high temperature in bearings, it does not appear to be generally understood that the bearing loads in Diesel engines are likely to be extremely unstable, that is, the unit load (pounds per sq. in.) in Diesel engine bearings, under certain conditions, may increase suddenly to many times the designed unit load. If, for instance, an engine has a tendency to have a sticky piston there are produced severe impact loads on the bearings which tend to squeeze the babbitt unduly and thereby cause fatigue cracking of the babbitt linings. Once such cracks are started, it is usually but a short time before loose "crumbs" of babbitt come out of the cracks and begin to obstruct the flow of oil so that the bearing heats up excessively and melts. Nearing overloads are undoubtedly the primary cause of the majority of bearing failures in Diesel engines.

The most important precautions for the preservation of Diesel engine bearings are the following:

Use only the best lubricating oil and renew the oil at regular intervals expressed in operating hours as prescribed by the engine manufacturer.

Limit the oil temperature from the bearings to 130 deg. F. If necessary, install an oil cooler in order to obtain this temperature.

For engines having pressure lubrication, it is desirable to have an automatic fuel cut-off device which is actuated when the oil pressure drops dangerously.

For engines having pressure lubrication there should be at least an alarm device such as a siren which will operate through an electrical contact that is made by a low oil pressure condition.

For engines having pressure lubrication always check to see whether oil pressure has been established immediately after the engine is set in motion. The position of the oil pump relative to the oil sump should be such that the pump is automatically primed. When, on any engine, trouble has been experienced because the oil pump does not function immediately upon starting the engine, there should be installed a small hand operated plunger pump for priming the main oil pump before the engine is started.

Sludge should be cleaned out from the crankcases and the oil piping at regular intervals expressed in operating hours.

The correct oil level in the oil sump or reservoir should be maintained at all times.

For the majority of crankcase-scavenging type engines it is possible to apply only the first and last two recommendations because in such engines there is no pressure on the oil in the bearings.

Main bearings of crankcase-scavenging engines are usually oiled by means of rings which dip in a small reservoir provided under each bearing. The crank bearings are oiled by a centrifugal oiling device attached to each crank. The lubricating oil that is spilled from the crank bearings and from the pistons into the crankcase is constantly voided into the "used oil" sump from which it is pumped by the "used oil" pump to the oil filter tank and reservoir.

To maintain the lubricating system on such crankcase-scavenging engines properly the following routine is recommended.

At least once each day lift the covers of the main bearing caps to see that the main bearing oil rings are running properly. See that the lubricating pump is maintaining the oil in the lubricator to the level of the overflow. Check the feeds of the lubricator.

Once a week, clean the lubricating oil sump at the governor end of the engine. Remove the plugs from the bottom of the lubricator to drain off water and sludge. Clean the oil filter.

Once every three months drain the entire lubricating system and wash out, with kerosene, all sediment from main bearing reservoirs governor housing, oil storage tanks, lubricator oil pumps and piping.

PRACTICAL HINTS AND KINKS

Tracing Faint Blue Prints

By Thomas D. Maher

WHERE it is necessary to make rough drawings or sketches in the field or on the job which have to be traced over old and often faint blueprints, use clear cellophane sheets for the overlay and draw on them with wax crayon which is used for marking glazed surfaces such as china ware. A sketch or drawing made this way may be fixed to be weatherproof by spraying with an ether collodion mixture by using an ordinary spray of any kind. Such prints can be used as a photographic negative by turning them over or reversing same before photographing. This material can be purchased from any stationery store.

How To Repair Wire Screens

By N. G. Near

IT IS easier to patch a hole in wire screens than most people realize, by using the following simple method. I have used this method successfully many times.

Cut off a patch of ample size for covering the hole, and as indicated in Fig. 1 strip some of the wires from all of the edges. This leaves wires projecting out in all four directions as shown in the sketch.

Then carefully bend the projecting ends perfectly square with the plane of the wire screen, as indicated in Fig. 2.

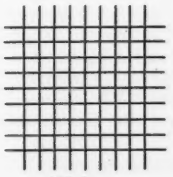


FIG. 1
STRIP OFF WIRES LIKE THIS

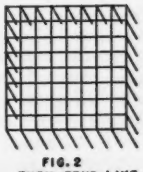


FIG. 2
THEN BEND LIKE THIS

Then place the patch over the hole, pushing the projecting ends through the meshes of the screen being patched. Clinch the projecting ends on the other side of the screen.

The patch will hold surprisingly well. While the patched screen does not look as presentable as an unpatched screen, it looks much better than a screen with a hole in it. Besides, from a practical man's standpoint it is *far* better than a screen with a hole in it.

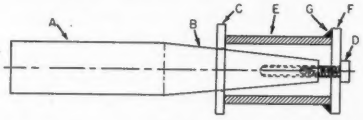
Lathe Accessory for Turning Down Washers

By John E. Hyler

ONE of the jobs that arises from time to time, and that is very difficult unless one has made special provision for it, is the reduction of the diameter on the outside of standard washers to make them adaptable for some special purpose. A lathe accessory that is so designed as to accommodate washers of many different sizes is shown in the sketch, which will hold the washer to be machined perfectly firm and true.

The basis of the device is a short piece of shafting A, which has been turned to perfect truth, including the turning of a taper B at one end. The tapered end B will naturally accommodate the firm mounting of any washer C within its scope. The tapered end is drilled axially, and is tapped to receive an ordinary machine bolt D as shown. This piece of shafting is simply held in the lathe chuck when in use.

A cup-shaped member is made up by welding together a piece of pipe E, shown in longitudinal section for clarity, and a cap F, the latter being a simple disk of relatively heavy steel, drilled to receive the bolt D with an easy fit through its center. The arrangement is such that the edge of the cup bears against the washer C, holding it firmly and with truth against the resistance of the taper on A, as it is driven up by the pressure of the bolt D



bearing against F. It will be noted that F is made enough larger than pipe section E in diameter to allow for the depositing of weld metal around its edge as at G.

In cases where there is a wide range in washer size to be met with, it may pay to have more than one cup member of different depths, or more than one bolt D of different lengths. Either method will give the same results.

PLANT OPERATION

Some Operating Whys and Wherefores at Derby

By John B. Saxe,
Gibbs & Hill, Inc., New York City

EDITOR'S NOTE:

A plant description must of necessity deal with the more general features in order to give the reader a comprehensive picture of the plant as a whole. For this reason details must be passed over with but brief mention on the assumption that the fundamental engineering principles involved are apparent to the reader. In editing the manuscript for the article "Derby Tops" by C. O. Lenz and John B. Saxe (describing the new addtion to the Derby Gas & Electric Co. plant at Derby, Conn., and appearing on page 762 of this issue) the editors noticed a number of points sufficiently novel to warrant more detailed treatment. The authors were asked to comment specifically on three points:

"1. Steam-mechanical atomization oil burners are being used to an increasing extent especially in the northeast and as this is a comparatively recent development we believe it would be well to outline the reasons for this and the advantages over straight steam or mechanical atomization.

"2. With a reasonably flat boiler superheat, or rather total steam temperature, characteristic, the exhaust temperature of a turbine, operating at constant exhaust pressure, rises quite rapidly at low loads. In a top plant a desuperheater is often necessary to prevent damage from the old low temperature equipment during these low load periods. The method used to control this temperature automatically and the proper design of the superheater is, we believe, unique and warrants the inclusion of further data on the drop in steam temperature at the throttle necessary at partial loads to give the desired result at the turbine exhaust.

"3. Specific mention is made of the fact that furnace pressure control is tied in directly with the steam pressure regulator with later correction from the furnace pressure regulator. This is undoubtedly due to the fan drives used but it departs from usual practice with the furnace pressure regulator independent and having complete control. For this reason we believe that a further discussion of the characteristics that make the arrangement used a desirable operating feature would be advantageous."

The reply to these suggestions came in the form of a letter as follows:

AS YOU STATE steam mechanical and straight steam atomizers are being used to an increasing extent in the northeast. In the plants within 100 mi. or so of the seaboard, the majority of boiler installations now provide for combustion of both pulverized coal and fuel oil. Generally speaking oil has been cheaper for about six out of the last 11 yr. in this territory.

Furnace design is governed by the requirements of coal firing where ash is handled dry and a relatively cold furnace is essential to avoid slagging. The advantage of the steam-mechanical or straight steam atomizers over a straight mechanical atomization is that the carbon and unconsumed hydro-carbon losses in a relatively cold furnace are reduced sufficiently by steam atomization to overcome the steam losses and result in a net gain. Also, steam atomization is much better adapted to meeting wide swings and to carrying light loads which was the major consideration governing the selection at Derby.

One manufacturer states that a 2 per cent loss for unconsumed carbon and hydro-carbons is allowed in their performance specifications with straight mechanical atomizers, while no allowance is made for these losses with steam mechanical atomizers. This difference seems to be confirmed by certain operating figures. One of the Connecticut plants recently installed combination burners and straight mechanical atomizers in boilers with relatively cold furnaces and found that their operating efficiency was 1½ per cent lower with oil than with coal. At Derby, with steam-mechanical atomizers, efficiencies equal to that guaranteed for coal firing were obtained on tests of oil firing in spite of the higher loss due to moisture from combustion of hydrogen, indicating a much lower carbon loss.

In furnaces with considerable refractory or designed for temperatures suitable for removal of ash in a molten state, there would be very small reduction in carbon loss, if any, to offset the steam loss. The advantage of steam mechanical atomizers with respect to straight steam atomizers lies mainly in greater capacity available per burner and also in smaller steam consumption, which is offset in part by the larger power consumption necessary to hold higher oil pressure at the burners.

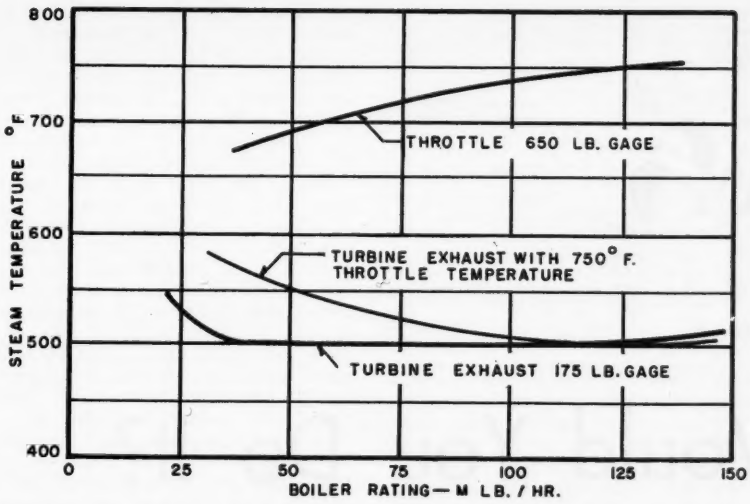
In this connection it might be of interest to mention that the Bunker "C" fuel oil being delivered in this territory today, fouls the air heaters with scum and steam atomization reduces this nuisance somewhat. To further reduce this the Derby operator, Mr. Sellers, fires both fuels in the same furnace on Friday afternoons, two burners on oil and two burners and one mill on coal. The fly ash from the coal scours the scum off the furnace and air heater tubes and they start with a clean unit on Monday. This procedure also keeps the coal equipment tuned up and ready for service.

TURBINE EXHAUST AND THE SUPERHEATER CHARACTERISTIC

Your question regarding the temperature of the turbine exhaust indicates that perhaps it has not been sufficiently stressed in the article. This is a very interesting feature and to my knowledge the first time it has been attempted. To answer your question and also to bring this feature out more strikingly, we are presenting, herewith, a chart showing the temperatures as a function of load.

This scheme originates in the fact that for the same pressure conditions the topping turbine reduces steam temperature a certain amount for a given flow irrespective of the initial temperature, within limits, of course. A superheater curve, giving constant temperature at the turbine exhaust was derived from the curve of turbine exhaust temperatures with 750 deg. F. at the throttle.

Boiler manufacturers were asked in the specifications to meet it, preferably



Temperature characteristics showing how the turbine exhaust at the Derby top turbine is kept witin safe limits without desuperheating by means of the builtin characteristics of the superheater

without controls. With these temperatures at the throttle there is a small difference in the overall heat rate at low loads, but in the upper range, where a topping unit must be operated most of the time in order to get proper results, the difference is negligible.

The boiler manufacturers engineers thought they could meet the desired curve very closely with a full convection characteristic but were unwilling to guarantee temperatures except at full load. Actual temperatures are almost exactly 500 deg. F. throughout the entire load range except at the point where the machine comes on the line and here the temperature rises to about 550 deg. F. which exceeds slightly the 526 deg. F. allowable on the old machines. The boiler is always cut in with the reducing valve and the piping arrangement is such that the temperature controller of the desuperheater could be located so as to desuperheat the turbine exhaust as the machine came on the line.

At normal loads it is possible to vary turbine exhaust temperature 10 deg. F. up or down by varying the excess air at the boiler. This arrangement represents the ultimate in operating simplicity and eliminates the complication, troubles, maintenance and first cost inherent in automatic damper control of steam temperature at the boiler and desuperheating equipment in the turbine exhaust.

The combustion control is arranged so that on impulse from the master controller, the air flow controller changes the speed of both forced and induced fans to meet the new requirements. If in this process furnace draft goes outside certain limits, the furnace pressure regulator changes the speed of the forced draft fan so as to maintain the desired furnace draft.

This arrangement is a necessary requisite in controlling air flow by varying fan speed without damper supplement. While the Sirocco design of fan used has the smallest wheel diameter and lowest inertia of any of the fan types, there is still appreciable inertia in the fans.

If the air controller changed the speed of the induced draft fan only and the forced draft fan followed on impulse from the furnace pressure regulator, sufficient lag would be introduced to cause hunting which probably could not be eliminated by adjustment of the controllers.

In practice the inertia of the fans proved to be less than that of the mills. However, on oil firing the response of the fuel oil was so much faster than the fans that a thundercloud would emit from the stack on a sudden increase in load. This condition was overcome by slowing down the oil controller and widening the range of the master controller from plus or minus 6 lb. to 12 lb.

After this change was made, good combustion conditions were maintained throughout without hunting when load was run up and down 30,000 lb. an hour as fast as possible with the topping turbine.

Control is not as close without the damper supplement but the number and size of control units is reduced, the control greatly simplified and maintenance on the dampers eliminated when the fans are merely wheeled along to meet the requirements.

We have just started work on the second boiler unit which has been ordered as a duplicate of the first.

Feed Pump Troubles

DUE TO THE FACT that boiler feed pumps handle hot water which has a tendency to flash into steam when the pressure is reduced, boiler feed water pump troubles are to be expected occasionally especially when the pump is running at high capacity and where the water does not come to the pump under a sufficient positive head.

When a reciprocating steam pump fails or refuses to pump water it should first be slowed down from 10 to 25 strokes per minute. Occasionally when the pump is steam bound a few buckets of cold water dashed over the water cylinder will rectify the trouble. Many feed pump installations are provided with an emergency connection taking water from an overhead tank and shifting the pump from the regular hot water to the emergency cold water supply may sometimes remedy the trouble. After the pump is working properly it can be shifted again to the regular supply. In making the shift be sure to open the valve to the regular supply before the emergency supply is cut off.

Some pumps are equipped with pet cocks on top of the valve chamber and if the pump is working it can be detected by opening the pet cock.

If only air escapes the pump is probably priming itself and will soon pick up water. If it does not, one or more of the suction valves may be stuck open. Often they will drop in place when the water cylinder is struck sharply with a block of wood or soft hammer.

Occasionally water, trash or dirt holds one or more of the suction valves open and water on that side will simply churn back and forth. Trouble of this kind can usually be located by means of a stethoscope or sounding rod. The type used by physicians is desirable but a short piece of hard wood placed between the teeth and held against the pump will usually give a clew as to the trouble.

It is well to practice using the stethoscope or listening rods when the pump is operating normally so as to learn how to detect the difference in sound when it is not working properly.

Underground Steam Line Pointers

TEMPORARY or semipermanent installation of steam and return lines underground where time and money do not permit use of regular types of duct for the pipes: as follows: Use double standard thick covering on the steam line and standard thick on the return; lay in ditch or trench on pipe rollers or on brick or stone supports where expansion is not a factor; cover with insulation in regular manner; then install tar or asphalt paper wrapping in sections and secure same with soft iron wire every 12 inches; thoroughly coat with pitch or asphalt compound at all joints and seams and over entire paper surface; then apply another paper covering, taking care to break and stagger all seams and joints and thoroughly coat the second paper covering. This will stand up and do a good job if made tight, even when subjected to salt water. Of course, backfill should be carefully placed so that no large rocks, bricks, etc., come in contact with the covering. (This is covered by a Navy specification.)

—got their whiskers tangled up.

How Would You Do It?

BETWEEN THERMAL RELAYS, trick switches, fuse arrangements and curious circuit schemes, our hero has been all but swamped with solutions to his rectifier tube problem presented in the October issue. They started rolling in almost before the last copies of the magazine came off the presses and have been coming in steadily ever since. One of the first to fire a solution at us was that versatile genius—that expert electrocutionist, Pulverizer Pete. His genius shone through his solution with a brilliance that all but blinded our board of judges, in fact they got their whiskers all tangled up in their excitement over it. And yet, they award him only second prize.

Strangely enough, Pulverizer Pete's solution, among others who solved the problem the same way, was the very solution our hero was looking for. Our hero, it turns out, is somewhat of a species of polecat—he knew the answer all the time. He had worked it out himself and was so inflated with his opinion of his own cleverness that he could not resist the impulse to see whether there was anybody else as clever as he. Well, as it turned out, he became the victim of his own ego because some of you went him one better and sent in solutions that proved to be even better than his own.

Being somewhat of an electrical genius himself, our hero had worked out an ingenious fuse arrangement which provided a high degree of protection of the tubes against improper manipulation of the switches. The scheme worked like a charm and many times during the years that it has been installed it saved the tubes from damage. It was this same arangement that Pulverizer Pete and several others proposed and, as will be seen, it is simple, practicable and foolproof.

There is, however, an even simpler solution to the problem; one employing neither fuses nor relays nor trick switches of any kind. All that is required are two D.P.S.T. switches and a simple wiring scheme. With this arrangement, as shown in Fig. 1, whichever switch is closed first closes the filament circuit and the remaining switch then closes the plate circuit. More than that, whichever switch is first opened removes power from the plates leaving the filaments heated. It is even more practicable than the fuse arrangement and has the added advantage that it is never inoperative due to a blown fuse.

Five others[1], besides Max Domras to whom first prize was awarded, submitted this solution. The award to Mr. Domras was based on his excellent analysis of the problem, not only in working out the solution but in his obvious understanding of other elements connected with the problem.

Pulverizer Pete's solution speaks for itself. It pained the judges to have to award a prize to this modest violet, but despite his misuse of the King's English, his brilliant genius shows through and they had no alternative but to give him second prize. His analysis of the problem is excellent, he displays a knowledge of other more conventional ways of solving the problem and describes the action of his fuse arrangement in a vivid, realistic, almost dramatic manner.

The third award goes to C. E. Kaufman of Pittsburgh, Pa., who also submits the fuse method. His circuit is slightly different from Pulverizer Pete's in that he only uses single pole switches but the principle remains the same. He also shows a method using a warning buzzer which is novel but, as he points out, would not be foolproof with an operator who was deaf, dumb or blind.

FIRST PRIZE AWARD

Problem IV

By Max R. Domras

Economical protection, the bugaboo of all power plant men, confronts our unsuspecting hero. But, with the installation of two double pole single throw switches and a few wiring changes the chagrined factory superintendent has the answer and our hero advances one more rung up the ladder of success.

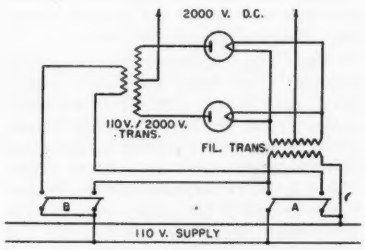


Fig. 1

Fundamentally, any solution to problem No. 4 must provide protection to the two hot cathode mercury vapor rectifying tubes. Therefore, as a result of the economical restrictions stated in the problem I have selected the following method of solution for both its simplicity and cheapness.

The circuit as shown on the accompanying diagram consists of two double pole single throw switches in series with the primary of the high potential transformer supplying the plate circuit. Then by tying one side of the primary of the filament transformer to the supply line and paralleling the other side to both the switches it becomes impossible to switch on the plate circuit without first having energized the filaments.

After the above wiring changes have been made, only one point remains unsolved. In the circuit diagram given with the statement of this problem two switching points were shown; namely, "A" and "B". Point "A" controls the filament circuit, and point "B" controls the plate circuit. Applying this reasoning to the new circuit diagram accompanying this discussion one can readily see that either switch can be designated

[1]Carl A. Myers, Grand Rapids, Mich.; Raymond Smessart, Chicago, Ill.; John P. Sheehan, Carthagena, Ohio; Frank H. Broome, Pompton Lakes, N. J.; Robert W. Johnson, Providence, R. I.

as "A" or conversely, either switch can be designated as "B". This is true because the first switch that is operated energized the filaments and thus becomes switch "A". The plate circuit then becomes energized when the second switch, or "B" is operated.

This hookup partially eliminates the danger of human error due to incorrect switching sequence. I say partially because the danger of insufficient warm-up time still exists. For safe operation the filament of a mercury vapor rectifier should be allowed approximately 30 seconds to heat before the plate circuit is energized. Therefore, absolute circuit protection would require the addition of a time delay relay. A relatively simple relay circuit could consist of another small diode rectifier circuit supplying a relay containing the main plate circuit switch. With this hookup the time delay characteristic can be obtained by putting a rheostat in the filament circuit of the diode rectifier. But, since our hero does not wish to take on the additional expense of a time delay relay circuit, the two switch circuit previously described will produce very satisfactory results.

SECOND PRIZE AWARD

Problem IV

By Pulverizer Pete

This hero guy sure keeps you and me busy. If it ain't thermo, its hydraulics or maybe mechanics and now its electrics. What he really needs is a versatile genius, but lucky for you (and me if you gives me a prize) I am a expert electronicist. So I now tells you how to fix your Hero up.

Now it seems like it would be ok to put the primary of the high-voltage transformer across the primary of the filament transfomer so they both works from one switch. But you says you wants a delay—so you wants a delay and a delay you is gonna get.

If I was riggin this rektifire up I would use a thermostatic switch in the primary circuit of the high-voltage transformer and have the thermostat switch closed by heat generated by a resistance across the primary of the filament transformer. But you says interlocks is out and you might call that an interlock and not give me more than second prize so I ain't gonna tell you about the thermostat idear.

So here is where I tells you about a simple way how to do the job. All you gotta get is a double pole double throw toggle switch and a fuse which just carries the high-voltage transformer. The toggle switch has gotta be the kind which is either one way or the other and wont stay in the middle where nothing gets connected.

Now, you uses the toggle switch for to connect the filament transformer and connects it like I shows on the picture. The fuse you puts in the circuit just ahead of the high-voltage transformer switch, like shown.

You is now all set. With the filament switch in the position with the

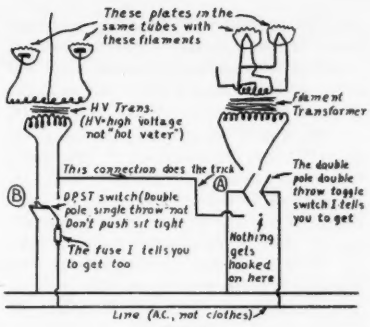

These plates in the same tubes with these filaments
HV Trans. (HV=high voltage not "hot water")
Filament Transformer
This connection does the trick
The double pole double throw toggle switch I tells you to get
DPST switch (Double pole single throw not Don't push sit tight
Nothing gets hooked on here
The fuse I tells you to get too
Line (A.C., not clothes)

Fig. 2

filament transformer off what have you got? You got a short across the high voltage transformer primary if you close switch B. So you close switch B first and what happens? Pouf! You blow the fuse. You tries it again with a new fuse and what happens? Ans. The same thing. By this time you should be sick a puttin in new fuses and you tries closin switch A first. What happens? The rektifire filaments emits a beautiful glow and you has incidentally removed the short from the high-voltage transformer primary. And now you can close switch B and proceed to fiddle with your d.c. output.

By this time you should realize from studyin the circut I cends that you cannot put juice on the rektifire plates before you turn on the filament supply which if I remembers right you wanted to find out how to do for your Hero. The delay you get depends on how long it takes to get from one switch to the other which should be enough.

THIRD PRIZE AWARD

Problem IV

By C. E. Kaufman

At first glance it seemed practically no problem at all for our hero to devise a simple switching arrangement. By using two S.P.S.T. switches as in Fig. 3A no current could flow through the power circuit unless the filament circuit were on. However, this layout does not preclude the possibility of starting current through both circuits at the same time. If switch B is put on first, nothing will happen. If it is left on while switch A is thrown, the filament current will not flow first but simultaneously with the power current and the tubes may be damaged.

Consideration of the drawback mentioned above might lead our hero to a solution such as is diagrammed in Fig. 3B. Switch B, as before, is of the SPST variety, but switch A is a SPDT toggle switch. If switch B is indavertently thrown first, no current passes through either the power or filament circuit, but a warning buzzer or perhaps red light will be supplied "juice" and should galvanize the operator into throwing open switch B. If switch A is first thrown and then B, no buzzer or light will startle the operator.

On thinking this solution over, our hero might imagine an operator who was deaf, blind, or mentally of a low order and who would not respond to his signalling apparatus. For such a man or as a general measure to insure safety he might adopt the scheme of Fig. 3C. Here again switch B is SPST and A is a SPDT toggle switch.

Problem No. 6

Our hero, this month, finds himself up against a really tough yet apparently simple problem. He has a city water line carrying 75 lb. pressure entering the cellar of a building and feeding a sprinkler system. A 4 in. check valve is installed just inside the wall with a pressure gage on the inlet side of the check and another gage on the outlet side. Starting with equal pressures on both sides of the check, the pressure on the outlet side will gradually increase over a period of three or four weeks to 125 or 135 lb. while the gage on the inlet side remains normal at 75 lb. On draining a gallon or two of water out of the sprinkler system, the pressure comes back to normal. The temperature of the building varies from 80 to 90 deg. during winter months. The height of the piping for the sprinklers is about 35 ft. It consists of a 4-in. header with 1¼-in. pipes leading from it. ¶ Our hero has puzzled over this peculiar action in vain and so he is putting the problem up to you. How can this pressure rise be accounted for and what steps can be taken to remedy it? He has suggested the installation of a relief valve but the powers that be did not think it wise. It would be another source of trouble and they are not sure as to the insurance company rules. The basement is used as a locker room and they are afraid a relief valve might at some time flood the cellar. What do you think is wrong and if you were in our hero's shoes, how would you go about solving it? No fooling—this is an actual problem.

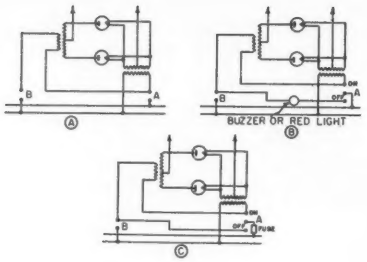


Fig. 3

Instead of a buzzer or light, a fuse of the proper rating is introduced into the circuit. When switch B is pushed on first with A in the off position with respect to filament current, a short circuit results, effectively cutting out both circuits until the fuse is replaced and the switches thrown in the proper order.

An objection to this method of control which might be raised is that at the conclusion of the testing period the fuse will blow if switch A is shut off before B. Switch A, of course, shuts off both circuits. It is conceivable that the operator would forget to turn off switch B after A, so if there were no fuse to automatically blow, the apparatus might be endangered when A was thrown on before the next testing period.

Another safeguard that possibly should be embodied by our hero in the design of a layout along the lines of Fig. 3B or 3C is the installation of switches A and B far enough apart so that they cannot be thrown at the same time by an absent-minded operator.

The decision to install a foolproof fuse circuit or merely a circuit which gives an audible or visual warning would probably depend, in our hero's eyes, on the type of operating personnel.

General Comment

These solutions, it will be seen, fulfill all the requirements set forth in the statement of the problem. No relays nor mechanical interlocks of any kind are employed and practically no investment is needed for equipment other than that specified. In either case, it is impossible to impress power on the plate circuit without also energizing the filament circuit. As pointed out by Mr. Domras, there is still danger of insufficient warming of the filaments, in other words it is possible to close both circuits practically simultaneously and under such conditions there might be some danger of tube damage, but there were no requirements regarding this point in the original statement of the problem, and with only 2000-v. on the plates the danger is small. With the location of the switches on opposite sides of the panel it can be assumed that there always would be some slight delay between the closure of the two switches.

It is to Mr. Domras' credit, however, that he considers this point and suggests the use of an additional diode rectifier together with a relay to bring about a time delay. This, however, would add considerably to the cost and it would seem that a small home-made thermal relay wold be more practicable.

As already mentioned, a number of other letters received also presented either of these solutions. Frank H. Broome of Pompton Lakes, N. J., used the same method as that of Mr. Domras except that he eliminates the necessity of permanent line connection to the filament transformer by the use of triple pole switches—a factor that might be of importance under certain conditions. As he points out in his letter, our hero (whom he has christened "Sava Tubortu") should not be concerned about whether switch A or switch B is closed first just as long as the current reaches the filaments first and the high voltage transformer next. He brings this point home with a story—

"Our hero, Sava Tubortu, is much in the same position as the "Y" Secretary in France during the World War. A piccolo player had just completed a number in the usual Saturday evening entertainment. Just as the secretary announced that the piccolo player would play an encore, some one in the audience called out 'Sit down, you big bum.' Whereupon the secretary announced that the program would not continue until the person who had called out identified himself. After a short

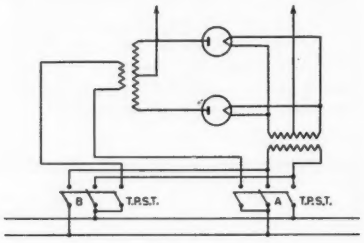


Fig. 4

period of uncomfortable silence, a gawky, loose jointed mountaineer, probably from Kentucky, pulled his joints together enough to get on his feet and drawled: 'Mr. Sec'tary, Ah don' think that it's a question o' who called the piccolo player a "big bum," it's who called the big bum a "piccolo player."' * * * Sava Tubortu is partly licked by a non-essential requirement[2] which, unfortunately, is typical of many which engineers are compelled to comply with.

"In this solution, if failure to meet a useless requirement[2] is construed as failure to meet all conditions, then it is assumed that the factory superintendent is a piccolo player. If closing the two switches in their proper order, however, is all that is needed to fulfill the conditions, then attention is called to the circuit shown in Fig. 4."

The circuit submitted by Carl A. Myers of Grand Rapids, Michigan, is similar to that of Fig. 1 and also

[2]Closing switches A and B in that order.

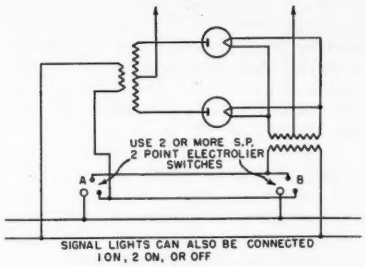


Fig. 5

uses two pole switches but in his letter he points out that the common connection to the filament transformer may be dispensed with by the use of two T.P.S.T. switches, which of course results in the circuit submitted by Mr. Broome (Fig. 4).

Another circuit deserving comment is that shown in Fig. 5 submitted by Robert W. Johnson of Providence, R. I. This circuit attains the same ends as those already considered except that it does so by the use of 2 point electrolier switches.

Other Solutions

Among the other solutions submitted were many involving unusual and ingenious ideas and while many of them were practicable nearly all of them were more complicated than necessary. In general the solution could be classified as follows: 1. Those using mechanical interlocks. 2. Trick switches. 3. Relays. 4. Signal lights. 5. The use of fuses. 6. Simultaneous closure of both circuits and 5. The prize winning method.

There were many involving trick switches ranging from the simple arrangement of William Sheffer shown in Fig. 6, to the complex homemade gadget of Albert Ogent, shown in Fig. 7. Built somewhat on the hour-glass principle, but using mercury instead of sand, it provides a time delay which may be controlled by means of a small thumb screw. The arrangement consists essentially of two test tubes interconnected by rubber tubing slipped over projecting glass tubes which themselves are held in place by rubber stoppers. The whole device is mounted so as to rotate around the vertical axis. The lower or suspended tube is partially filled with mercury. When

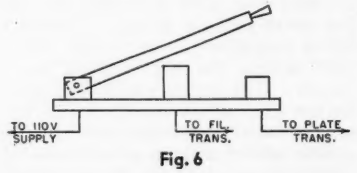


Fig. 6

the tubes are inverted the mercury contained in the up-ended tube drains into the lower tube, where as the level rises it eventually makes contact with a copper wire and closes the plate circuit. The rate of flow of the mercury can be adjusted to provide the required

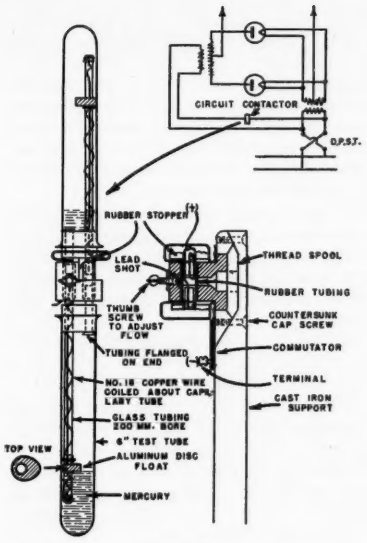


Fig. 7

time delay by means of a small thumb screw which squeezes the short length of rubber tubing connecting the two test tubes.

There is no question as to the effectiveness of this device in meeting certain of the requirements set forth in the problem and certainly it is inexpensive to make, but unless the arrangement was interlocked in some way with the D.P.S.T. switch, it will still be possible to energize the two transformer circuits simultaneously.

As a result of our analysis of the various answers received, we feel that we owe some sort of an apology to those who are not familiar with vacuum tube technique. In presenting the problem we stated that a knowledge of tubes was not necessary to solve the problem. This was perfectly true except for one thing and that was the element of some time delay between the closure of the two circuits. Many of the letters received suggested a common switch for both transformers. This made it impossible to energize the plate circuit *before* the filament circuit, but it permitted both circuits to be energized simultaneously and this, as anybody with some knowledge of tubes will perceive, is not a desirable condition.

In commenting on this John A. Grant of Danville, Ill., raises the question of the type of tubes used. He points out that the 866 shielded type mercury vapor tube with an inverse peak voltage of 10,000 v. or the 249 B heavy duty type require no delay for the usual pre-heating—that they will start in a few seconds. While it may be possible to dispense with pre-heating, still it is not desirable and even a few seconds heating will remove most of the danger.

Among the unusual mechanical interlock arrangements suggested, the one by C. F. Wetzel shown in Fig. 8 is of interest. It consists of two S.P.S.T. push button switches and a few metal strips arranged so that switch B is held in the off position until switch A has been turned on. Referring to Fig. 8, both switches are off and switch A is shown on the front of the box. To cut in the circuits, switch A is closed and the strip covering it is moved to the right. This permits the strip across the end to be moved forward and this in turn permits the strip at the rear to move to the left so that switch B can be closed. This arrangement is simple, foolproof and inexpensive but it would be rather awkward to adapt it to panel mounting.

Another quite practicable solution using a mechanical form of interlock is that outlined by George L. Schlaepfer of Grosse Point Farms, Mich. Quoting from his letter: "Both switches are to remain D.P.S.T. as shown in the original circuit diagram. They are designed to be operated with a removable key (or handle or lever as the case may be). Only one key is used so that the two switches must be operated successively.

"To insure proper sequence of operation, switch A is designed so that the key can be removed only in the closed position while switch B is designed so that the key can be introduced (or removed) only in the open position. With both switches open the key is locked in A when the switches are installed. Consequently, switch B cannot be closed until switch A has been closed and the one key has been removed and transferred to B."

This arrangement has considerable merit but it would take some ingenuity to make these key switches while, if purchased, they might be expensive.

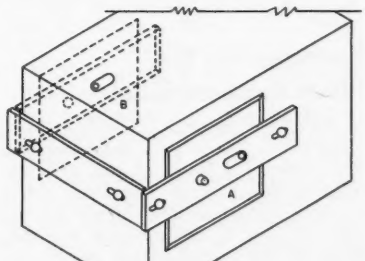


Fig. 8

A number of solutions provided thermal relays in the high voltage transformer circuit. In one case, that of F. W. Watts of the United Electronic Controls Corp. of New York, N. Y., this was a commercial thermal relay costing $6.50. This is a small enough outlay for such effective protection and the chances are that in nearly all cases this would provide the most practicable solution. However, since the element of economy was stressed in the statement of the problem, a number of letters outlined methods of making simple home-made relays. One such is shown in Fig. 9, that submitted by Harry A. Love of Fort Monroe, Va. As he points out in his letter, "Our hero's problem may be solved simply by the addition of a thermal unit which may be procured on the market at a cost of a few cents or, granting our hero a minimum of mechanical and electrical ingenuity, it may be made up in 30 min. in the most down-at-the-heel electrical maintenance shop in the industry. . . . The thermal unit consists of a bi-metal strip X on which is wound coil T, a resistance coil of insulated resistance wire, a pair of contacts C and an adjusting screw S, which is optional. The bi-metal strip is rigidly mounted at the end away from the contacts and the contact to which the bi-metal makes contact may be simply a fixed screw or a contact arm as indicated in the diagram. . . . In the event that our hero elects to construct the unit he might well purchase an

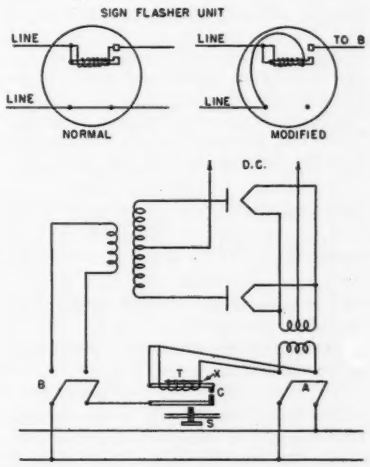


Fig. 9

ordinary sign flasher unit at a cost of not more than 25 cents and alter the circuits through this unit as shown in the small insert sketches. Since it is specified that the output of the rectifier is small it is probable that the contact area of the contacts in an ordinary sign flasher could carry the necessary current for the power transformer primary without danger of overheating or welding. . . . The resistance of the thermal winding is not critical except that since it is connected directly across the power line, it should be high enough to limit the current through it to a small value—a few milliamperes."

The idea of constructing a thermal relay out of a sign flasher deserves attention since it provides absolute protection at minimum cost. However, the two circuits first described also give a high degree of protection and, as already pointed out, the fuse arrangement has been in use for many years with excellent results.

Questions And Answers

You're Right—We're Wrong

On page 738 of the November issue of Power Plant Engineering, in the answer to the question on determining transformer capacity necessary to serve 50 25 hp. welder motors you stated that the total kilowatt load of the motors would be the number of motors times the horsepower rating of each motor multiplied by 746 and divided by 1000. There was no mention of the fact that the horsepower rating of a motor is always the horsepower output and must be divided by the efficiency in order to obtain the power input. In this case, assuming 95 per cent efficiency (which is somewhat high for welding motors) the total kilo-

matt load would be $\frac{50 \times 25 \times 746}{.95 \times 1000}$ which equals 981.6 KW or at 0.6 pf. the KVA load would be $\frac{981.6}{.6}$ which equals 1636 kv-A instead of 1554 kv-A determined by your calculations.

W. C. Morris, Jr.

Ed. Note. Mr. Morris is correct—the efficiency of the motors should have been taken into consideration in the solution of this problem. We stand corrected.

Series and Parallel Operation of Centrifugal Pumps

Q. Two similar centrifugal pumps are piped in series and deliver 250 g.p.m. against a total head of 100 ft. How much will the two pumps deliver when piped in parallel? L. W. D.

A. If the two pumps were repiped so as to operate in parallel, the two operating together would deliver 500 g.p.m. but only against a head of 50 ft. In the first case each pump must handle all the water, the first pump taking its suction from the well and delivering it to the suction of the second at 50 ft. head. The second increases the head by 50 ft. and discharges at 100 ft. (2.31 ft. of water is equal to 1 lb. per sq. in. pressure). In parallel operation each pump handles only half the total amount of water and each takes its suction from the same source and delivers to the same header. When piping pumps in series care must be exercised to insure that the casing of the second pump will stand the increased pressure which is obviously double the design value.

Cleaning Ammonia Condensers

Referring to the request by T. E. Hanson on page 611 of the September issue, the method I have found most effective in cleaning condenser tubes is to fill them with strong ordinary soda water and then to make a steam connection into the system so that it can be kept hot, as near to the boiling point as possible. The soda water should be kept hot for about six hours, which will soften the scale. Then circulate water over the tubes but not only in one direction; reverse the direction of flow frequently, say every two minutes. This treatment will remove the bulk of the scale which will be deposited with the waste water. There will be no damage to the tubes either by corrosive or mechanical action and the tube will be cleaned effectively. Reversing the flow is necessary so that the softened scale is undermined in both directions.

London, England. W. E. Warner

Formulas for the Heat Value of Coal

Editor's Note: Richard Murphy's request for a formula to determine the heat value of a pound of coal after an approximate analysis has been taken brought forth a veritable deluge of replies. Because of limitations in available space we can present only a few of the answers here, but we will try to publish others in succeeding issues. Some of the best answers, in fact, are too long to be presented in this section and will have to be published in the main body of the issue. One of these is the reply submitted by J. R. Darnell. His solution, as are most of the others, is based on the use of Dulong's formula, but as he points out Dulong's formula does not apply to high oxygen fuels and so he also presents a method for use with such fuels. This article will be published in an early issue. Some of the other replies follow:

The following formula will give in B.t.u. the heating value of any fuel correct to within two or three per cent.

$$V = 14{,}600\ C + 62{,}100\left(H_2 - \frac{O_2}{8}\right) + 4000\ S$$

in which V is the heating value of the fuel in B.t.u., C is the per cent carbon, H_2 the per cent hydrogen, O_2 the per cent oxygen and S the per cent sulphur. All percentages should be expressed as decimals.

This formula will give the higher heat value of the fuel. To obtain the lower value or the amount of heat left after all the water in the fuel has been vaporized, subtract from the above formula the following:

$$1040\left\{H_2O + 9\left(H_2 - \frac{O}{8}\right)\right\}$$

These formulas can be used for any hydrogen fuels. If there is no sulphur present it can be disregard d entirely as S then becomes zero. Nitrogen and ash can be ignored as they have no heating value. H. G. Scheer.

Houston, Texas.

* * *

First tell Mr. Murphy to buy himself a copy of the U. S. Bureau of Mines Bulletin which contains analysis of coals from almost every seam, country, mine and state in the Union. I think this bulletin costs about a dollar. Offhand I do not recall the number of the book, but I think the Bureau would have no difficulty in knowing the one I mean.[1]

The second step is to convert the proximate analysis to a moisture and free ash basis. Then look in the B. of M. book for a coal having that proximate analysis. Take the ultimate M and A-free analysis corresponding to the proximate and reconvert the ultimate to an "as received" basis. Apply the Dulong formula to this ultimate analysis; then decide whether to use the Dulong heat value, the one in the B. of M. bulletin, the average of the two, or send a sample to the laboratory in the first place.

Here is a typical example:

Suppose Mr. Murphy has a coal from Hocking County, Ohio, with the following proximate analysis:

H_2O	9.72		
V. M.	32.44	32.44	37.75
F. C	53.41	53.41	62.25
Ash	4.43		
	100.00	85.85	100.00

He now looks under Hocking County, Ohio, for a coal having a moisture and ash-free proximate analysis as near to the one he has as possible. He takes the corresponding ultimate, multiplies the values by .8585 and adds 9.72 moisture and 4.43 ash. He may then apply Dulong's formula and compare it with the heating value given for the coal. You can get pretty accurate results with this method. George P. Rettig.

Long Island City, N. Y.

[1] We do not know exactly which Bureau of Mines publication Mr. Rettig has in mind, but the Bureau has published a number of bulletins on this subject some of which are out of print. Bureau of Mines Bulletin, 193 entitled Analysis of mine and car samples of coal collected, 1916-1919, is still in print and can be obtained from the Superintendent of Documents at Washington, D. C., for 35c.

James O. G. Gibbons' reply also makes use of the Dulong formula. Quoting from his letter: "This formula,[2] in the case of coal with little moisture should generally give results accurate to within two per cent, but with only a proximate analysis available we shall have to use some modification.

"A SIMPLE formula which will give fairly accurate results with high volatile coal but which will probably be about ten per cent low with low volatile coal is the following: B.t.u. per lb. = 14,544 C + 16,515 V — 10,000 A. In this formula V is the fractional part of volatile, A the fractional part of ash and C that of the carbon.

"More consistent results probably will be obtained by the use of the following formula, attributable to Dr. C. E. Lucke.

$$\text{B.t.u. per lb.} = 14{,}544C + 27{,}000\ v\left(1-\frac{1}{\frac{C}{v}+0.5}\right)$$

"The following examples are taken from published tables and show how the results obtained by this formula check with actual values.

	Moisture	Carbon	Volatile	Ash	B.t.u.
A	3.44	73.46	16.18	6.92	14,114
B	9.67	46.39	35.92	8.04	10,833

$$A\quad 14{,}544 \times 0.7346 + 27{,}000 \times 0.1618\left(1-\frac{1}{\frac{.7346}{.1618}+0.5}\right)=14{,}223$$

$$B\quad 14{,}544 \times 0.4639 + 27{,}000 \times 0.3592\left(1-\frac{1}{\frac{.4639}{.3592}+0.5}\right)=11{,}030$$

"As will be seen these results are pretty near to those shown in the table. No extreme accuracy can be expected from this method, but it should be remembered that even with a calorimeter, although the test of a single sample of coal may be very accurate, only a continued series of tests can give the average B.t.u. value of the coal used during a given period.

JAMES O. G. GIBBONS

* * *

R. L. Rowan, fuel engineer of the General Coal Co. of Philadelphia, has this to say about the question:

"IT IS impossible to use one formula to determine the heating value of coal from the proximate analysis for all of the various coal seams in the United States. The heating value of the fixed carbon can be assumed to be 14,600 B.t.u. per lb. for reasonably accurate results, but the volatiles are made up of the combination of various combustibles that vary so from different seams that there is no one value that can be applied to all of them. It is possible, however, to determine the heating value of the volatile from a given seam in a given locality. To show how this varies, I am tabulating below data taken from the U. S. Bureau of Mines, monograph No. 5, tables 1 and 26 contained therein. The calculated calorific value from the abovementioned data is shown.

[2]Dulong.

CO_2 BONUS SYSTEMS, AND HOW!

In the October issue C. B. O. of New Hope, Pa., requested information on CO_2 bonus systems. Strangely enough, a month went by and none was forthcoming. So we repeated the request in the November issue, emphasizing the fact that everybody's ideas were equally welcome. Well, that started something; almost at once letters began to roll in, slowly at first and then rapidly. Just now they are still coming in—swell letters, letters crammed full of interesting facts and opinions about CO_2 bonus systems, letters that are of very definite value to C. B. O. They come from chief engineers and coal passers alike and as we pointed out the coal passer's ideas are often just as valuable as those of his superiors. We present a number of them in this issue, but we deeply regret that we have not room enough to publish all of them. They all are being forwarded to C. B. O., however. So we take this opportunity to thank you—all of you who have taken the time and effort to sit down and write us a letter. We will try to publish at least part of your letters, but if that proves impossible you can rest assured that your letter will reach C. B. O. and that he will appreciate it. Perhaps some time when you need help we can be of assistance to you in the same way.

Coal No.	Coal Bed	Dry Basis % V.M.	B.t.u. per Each % V.M.	B.t.u. in Total V.M. per lb. Coal
23	Pocahontas No. 4	15.5	222	3440
26	Sewell	21.1	202	4260
27	Sewell	27.0	186	5020
8	Mary Lee	28.8	176	5070
10	Illinois No. 6	34.9	144	5030
18	Pratt	32.5	173	5620
9	Pittsburgh, Pa.	34.3	168	5760
22	Pittsburgh, W. Va.	38.0	160	6080
14	Chilton	37.0	163	6030
2	Elkhorn	37.4	160	5980
15	No. 2 Gas	39.6	161	6380
19	Lower Sunnyside (Utah)	40.7	147	5980
3	Taggart	36.7	170	6240

You will note that the B.t.u. per each per cent of volatile matter varies from the different seams shown, from a low of 144 to a high of 222 B.t.u.

If Mr. Murray is using coals from only a few well defined seams, he can secure analytical data from the Bulletins of the United States Bureau of Mines, from which he can calculate the B.t.u. of the volatile matter. Then using this figure and 14600 as the calorific value of the fixed carbon per pound, he can arrive at a fairly accurate B.t.u. estimation of the specific coal in question.

R. L. ROWAN

Replies by C. C. Tinker of Lapeer, Mich, Tracy Nesbitt of Vienna, Md., Frank C. Caveman, Jr., of Cincinnati, O., Chester V. Chapman of Celina, O., W. F. Cantieri, of Dresden, N. Y., and others that may arrive after this writing will be considered in subsequent issues.

Circulation in H.r.t. Boiler

WHEN WATER boils in a kettle the water rises around the edges of the vessel, and tumbles toward the center where it descends. The currents are caused by the joint action of the added temperature and two or more qualities which the water possesses. Water expands when heated above 39 deg. F. Water is practically a non-conductor of heat, though not entirely so. The heated water cannot impart its heat to its neighboring particles. It remains expanded and rises by its levity, while colder portions come to be heated in turn, thus setting up currents in the vessel.

When all water has been heated to the boiling point corresponding to the pressure to which it is subjected, each added unit of heat converts a portion into vapor, and the mingled steam and water rises more rapidly, producing ebullition. If the fire becomes more intense the upward currents interfere with the downward and the kettle boils over.

If we put a partition so as to separate the upward currents from the downward we could force the fires without causing the kettle to boil over. Circulation increases the efficiency of a boiler by adding to the ability to take up heat and prevents what is technically known as priming.

If we could look into an H.r.t. boiler when steaming, we should see a curious commotion of currents rushing hither and thither, and shifting continually as one or the other contending force gained a momentary mastery. The principal upward currents would be found at the two ends, one over the fire and the other over the first foot or so of the tubes. Between these the downward currents struggle against the rising currents of steam and water. At a sudden demand for steam, the pressure being slightly reduced, the water jumps up in jets at every portion of the surface, being lifted by the sudden generation of steam throughout the body of water.

Gaylord, Mich. O. J. PIERESON

IN THE NOVEMBER issue of the Practical Engineer department of POWER PLANT ENGINEERING, F. H. Van Dyck of Worcester, Mass., requested information on the circulation of water in the H.r.t. type of boiler.

The following has been taken from the E. Keeler Co. catalog on return tubular boilers—"Facts on Circulation":

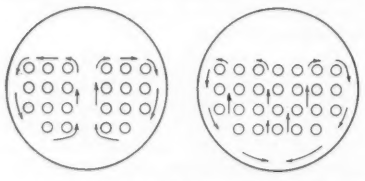
"Considerable controversy had taken place, prior to 1922, concerning the water action (circulation) within the H.r.t. boiler. To verify the opinions held by engineers throughout this country a National Contest was conducted and 54 engineers' associations submitted their opinions as to what this action was. The judges were F. R. Low, Editor of "Power" and John Lane, Editor of "National Engineer"; they were provided with a working boiler model built by E. Keeler Co. for their use in making their study. After considerable time spent in studying the operation of this boiler, using a strong microscopic glass to trace small objects placed in the water, it was observed that there is a pronounced and definite water circulation within this type of boiler.

"The result of the study is as follows: The water travel is in the form of a figure eight in a horizontal position. Starting at a line approximately at the bridge wall the flow of the water is along the bottom of the shell toward the front boiler head where it is deflected upward above the normal or cold water level, then rearward to approximately two-thirds of the length of the boiler where the flow dropped downward to the shell, along the bottom of the shell to the rear head, where it was again directed upward to slightly above the normal water line where it turned, forming the small loop of the figure eight and dropped down to the place of beginning."

This opinion is held by a good number of operating engineers and it is about the most logical opinion set forth that bears looking into and which can be substantiated with facts.

Williamsport, Pa. K. A. PIPPART

PERHAPS THE accompanying sketch will answer Mr. Van Dyck's question on circulation of water in H.r.t. boilers.



In recent years boiler manufacturers are omitting the center row of tubes in boilers, by doing so rapid circulation is created in the boiler. It brings a maximum amount of water in contact with heating surfaces in a minimum time.

In boilers without center row of tubes omitted, the water on being heated rises to the top and then has to find its own way down since no path is provided.

Cleveland, Ohio

MICHAEL G. FEREK

Can He Use Superheated Steam in His Ironer?

Q. I HAVE a cylindrical ironer in our laundry which has very low efficiency due to lack of heating surface. I would like to increase this efficiency by raising the temperature through the use of superheated steam.

The working temperature, taken between the ironer and the trap is 336 deg. F. at the present time and my idea is to raise the steam temperature to about 450 deg. F. by diverting enough steam from the boiler through a superheater utilizing stack gas which has a temperature of 630 deg. F. allowing 120 sq. ft. of heating surface to superheat the 12 hp. per hr. of steam necessary to supply the ironer.

I would appreciate comments of other readers on this plan. Is it practical or not?

Sacramento, Cal. P. H. C.

What! No. CO_2 Bonus Systems?

WHEN C. B. O.'s question appeared in a former issue my reaction was to leave the answer to the "big-wigs" but as none of these have been interested—and if C. B. O. should prove to be entirely bald—possibly a small wig may be better than no wig at all.

To begin with his boilers and furnaces should be put in first class repair and the fuel the best adapted to the furnace and general conditions affecting the plant.

He should then determine the average per cent of CO_2 that can be maintained by proper stoking and use of the proper draft, the average per cent of CO_2 that can be maintained without special effort, everything having first been put in first class condition.

Now as to the distribution of the savings effected, the bonus. Here it is hard to prescribe because like many other questions submitted to your magazine for comment, detailed information is lacking. Does he have one fireman, or twenty-five?

Suppose he has ten. If he should decide to return 10 per cent of the savings to each fireman, nothing at all would be left.

To be appealing to the fireman and secure his best efforts, the bonus should amount to 50c. or more per day.

The company can afford to distribute 50 per cent of the savings effected among the men responsible for the saving, prorated according to each man's combustion efficiency as shown by his CO_2 percentages. In case there is a head fireman or an engineer supervising the fireman, he should share in the distribution in order to enlist his cooperation in seeing that the men under him are furnished needed supplies without delay.

Inasmuch as C. B. O. is himself an engineer, it will be unnecessary to advise as to how to determine the amount of savings effected by each per cent of CO_2.

Meadville, Pa. T. R. EWING

IF YOU REQUIRE the description of a CO_2 bonus system that pays out "folding money" for high CO_2 averages, don't waste your time to read any further, just feed this to the waste basket.

Here's a CO_2 system in a refinery boiler house that works and what's more, our fuels vary from -2.0 deg. A.P.I. cracked residuum to refinery gas. Many times the fuels or combination of fuels must be changed three or four times per hour, yet we have an efficient CO_2 system.

Two years ago one of the firemen, who had fired eight years, was put in charge of the boiler house. His first move was to repair the settings and doors of all the boilers, his second move was to get modern burners and observation doors installed. After reducing his fuel costs as much as possible this way he turned his attention to instrument firing.

No! We did not put in CO_2 recorders and start the CO_2 system immediately. A straight CO_2 system is about as efficient as firing a boiler with a pressure gage.

Before even attempting to set up a CO_2 system we made a thorough investigation of our fuels. This involved running anaylses on both the oils and gases. Next we had all our instruments overhauled, steam and air flow pens were set by a company representative, four point draft gages were repaired at factory, thermocouples in boiler breechings and superheater outlets were all checked. Complete routine flue gas analyses that had been run for the three previous years were used to determine average fuel characteristics so the efficient excess air could be used in setting the steam flow-air flow pens. (Of course more analyses were run while the pens were being set.) Calibration charts were then made up for the steam flow-air flow pens for each combination of fuels. An hourly log sheet was then started, recording all the readings essential to good operation. These values are averaged by the chief engineer each day and posted on a monthly graph in plain view of all the operators.

After all of this had taken place two good CO_2 recorders were purchased and installed on a common manifold. Each day on routine furnace checks the CO_2 recorders are checked. CO_2 ranges have been typed and glued on the front of each recorder for each fuel or combination. Stack loss charts are posted so the fireman can check his excess air and approximate stack loss from the respective chart.

The daily average CO_2 for each fireman and his assistant is posted by the chief engineer. Each two weeks the chief engineer reports the highest, lowest and average CO_2 to the fireman for his report. This friendly rivalry has been worth thousands of fuel dollars saved.

Mr. C. B. O. a CO_2 Bonus System is a fine thing if conducted properly, but the installation of a CO_2 recorder does not mean a solution of your fuel problem. You probably already know the combustion characteristics of your fuel, set up a stack loss chart, showing CO_2, O_2, excess air and stack temperature,

cross-section it with colored pencil, showing the CO_2 ranges which are dangerous (CO), good, fair, and bad. Instruct your men about the meaning of the chart and make sure several Orsat analyses are made against the recorder once a day. Conduct blind firing tests, have your men fire for part of the shift without instruments and then show them how much more efficient and easier it is to fire with instruments.

Double check your CO_2 bonus checks with an Orsat check. Post your results daily where each man can see them and at the end of the month you'll have a hard time determining just who deserves the bonus.

Augusta, Kan. J. C. DE FOE

MR. C. B. O., New Hope, Pa.: What, no Bonus System? NO, because more grief and hard feelings have come to firemen and engineers from CO_2 bonus systems than from a lot of other things combined. If your furnaces are not equipped with draft and steam flow recording charts you are headed for trouble sure. You will not know what is being done to produce high CO_2. You may have high CO_2 and incomplete combustion which in turn is liable to show a high percentage of CO. In the effort to produce high CO_2 the fires may be starved for the lack of oxygen and mighty hot fires are sure to result in destruction of the brickwork. The same high CO_2 could result from a thick heavy fire since not enough oxygen would get through to effect complete combustion, though with this condition it would be more difficult to produce the required amount of steam.

I think if any CO_2 bonus systems are started, and it is questionable in my mind whether they should be started at all, they should be worth a little foresight and study of conditions in the plants where they are to be used. Accurate coal analyses should be available so that the theoretical air requirements can be determined. This may be a little difficult and complicated but I shall be glad to supply information as to how to go about it. LEO S. SWART

Newark, N. J.

How Can Cylinder Oils Be Tested

IN TRYING to answer Mr. Richard E. Murphy's question, one must realize the operating engineer is seldom in a position to make elaborate tests of lubricants. In many cases, however, the operator can make simple practical tests of lubricants. There is no pretense that they are accurate in determining the commercial values of lubricating oils but they will serve to guide the engineer in the selection of his lubricants; besides they have the merit of being applicable in ordinary engine room practice.

TESTS FOR ACIDS AND ALKALIS

Place a small quantity, say a teaspoonful, of the oil or grease to be tested in five or six times its bulk of boiling water, and dip into it a piece of red litmus paper; if the litmus paper remains red after having been soaked in the mixture for a considerable length of time, the oil or grease is acid. If the color of the paper turns to dark blue quickly, the oil is alkaline. If it changes colors very gradually to light blue, the oil is neutral.

Before this test is made the water to be used must first be tested with litmus paper to see whether any discoloration of the paper will result. It may be that the water itself is slightly acid, in which case the oil tested would be of no practical value.

TEST FOR VISCOSITY

Pour a few drops of each sample oil upon a large sheet of tin or glass while the sheet is perfectly level, then raise one end of the sheet gently about one inch and support it in that position; watch the race of the drops of oil on the inclined plane. The oil that reaches the bottom of the plane last ranks highest in viscosity. Of course, this is only a comparative test, but it will enable the operator to select from a number of samples the oil best adapted to his purpose.

SPONIFICATION TEST

The presence of animal or vegetable oils in a lubricant is detected as follows: Place about a pint of oil into a small iron boiler or saucepan and add 1 to 2 ounces of caustic soda or concentrated lye; boil the mixture for half an hour and then set it aside to cool. When thoroughly cool examine the mixture, if the surface is covered with soap, the oil contains animal or vegetable fats; otherwise it is pure mineral oil.

PRECIPITATION TEST

To ascertain if the oil contains paraffin, waxes, gums, etc., place an ounce of each of the oils in a separate half pint bottle, pour 2 ounces of gasoline into each bottle on top of the oil, and shake the bottles until the oil is dissolved by the gasoline; then allow the mixture to settle. If there is a considerable amount of sediment in any of the bottles, it indicates that the oil in them has been treated to produce artificial viscosity.

TEST TO DETECT SULPHURIC ACID IN MINERAL OILS

Heat a small portion of oil to 300 deg. F. in a metal cup and pan of sand and maintain that temperature for about 15 minutes. After cooling, if the sample is considerably darker in color than the original, it contains sulphuric acid.

TEST OF CORROSION

Place a clean copper strip in oil for 3 hours at a temperature of 212 deg. F. If after 3 hours the copper strip is its natural color, the oil will not corrode.

As an operator in Diesel and steam power plant the last 3 years, I realize the problem of lubrication is one of the most important factors in good operation of machinery.

I hope this will help Mr. Murphy solve his problem. Although there are more tests Mr. Murphy could make, I don't believe they are so important as the ones I have just covered.

NORMAN KING

Charlevoix, Mich.

REPLYING to the question on page 737 by Richard E. Murphy in the November issue of POWER PLANT ENGINEERING, the writer wishes to state that the methods of testing cylinder oil as set forth below are not original, but that they are methods which have been used and proved satisfactory.

The following tests are not accurate in determining the commercial values of lubricating oils, but merely act as a guide in helping the engineer select the proper lubricant.

1. Viscosity
   Place a sheet of tin or glass in a level position and pour a few drops of each sample of oil on the sheet. Tilt the sheet slightly and watch the oil as it moves downward. The oil that reaches the bottom last has the highest viscosity.
2. Acids and alkalies
   Add a tablespoon of oil to about a cup of boiling water and dip into the mixture a piece of red litmus paper. If the paper remains red after being soaked in the mixture for a short period, the oil is "acid." If the paper turns to a dark blue quickly, the oil is "alkaline." If the color changes to a light blue very gradually the oil is "neutral." As a check use a piece of blue litmus paper in the same manner. If it remains blue the oil is "alkaline." If it turns red quickly the oil is "acid." If it changes slowly to a light red the oil is "neutral."
3. To detect animal or vegetable oils
   Place about a pint of the oil in a pan and add 1 or 2 ounces of caustic soda or concentrated lye. Boil the mixture for half an hour and allow to cool. If the surface is covered with soap the oil contains vegetable or animal fats. If not, it is pure mineral oil and suitable for cylinder use.
4. To detect paraffin, waxes, gums, etc.
   Place about an ounce of the oil in a bottle and pour about 2 ounces of gasoline on top of the oil. Shake well until the oil is dissolved by the gasoline and then allow it to settle. If there is a considerable amount of sediment in the bottle it shows that the oil has been "doctored" and unfit for cylinder use.
5. To detect sulphur in mineral oils
   Pour a small amount of the oil in a metal cup and place the cup in a metal pan filled with sand. Heat the pan until the oil has reached a temperature of 300 deg. F. and allow to cool. If the oil turns considerably darker than the original sample, it contains sulphur and should be rejected.
6. Flash and burning test
   Use the same procedure as for the above test for sulphur. When the oil reaches 300 deg. F. pass a lighted match over the top of the cup. Repeat every few degrees rise in temperature until the vapor arising from the oil ignites with a flash. This is the "flash point" of the oil. Continue the test until the oil ignites and burns on the surface. This temperature will be the "burning point."

CLIFFORD F. SMITH

Saginaw, Mich.

Types and Characteristics of Electric Motors

Type of Motor	Service	Starting Duty	Speed	Regulation	Max. Torque—% Full Load	Remarks
Direct Current						
Shunt Wound	Gen. Pur.	Medium—150%	Constant	Close—3-7½%	Limited by commutation	About 25% increase in speed possible by field control. Suitable for steady loads: fans, stokers, lathes, planers, agitators, mixers.
Series Wound	Spec. Ser.	Very Heavy—300-400%	Constant	Wide—depends on load	Limited by commutation	For hoists, cranes, valves, balers, traction. Must be geared to load.
Compound Wound	Spec. Ser.	Heavy—175-200%	Constant	Wide—10-25%	Limited by commutation	For flywheel loads and other widely fluctuating loads which occur less than 25 times per minute. For compressors, conveyors, crushers.
Polyphase Alternating Current						
Squirrel Cage						
Normal torque, normal starting current	Gen. Pur.	Medium—150%	Constant	Close—3-6%	175—200%	The simplest and most widely used motors made. For fans, lathes, grinders, stokers, agitators, pumps, mixers.
Normal torque, low starting current	Gen. Pur.	Medium—100-150%	Constant	Close—3-6%	200%	Designed to start on full voltage. For fans, blowers, centrifugal pumps, planers, lathes, stokers.
High torque, low starting current	Spec. Ser.	Heavy but at not too frequent intervals—175-275%	Constant	Close—4-6%	175—200%	Across the line starting. Especially applicable to pumps, compressors, conveyors, crushers, pulverizers.
Low torque, low starting current	Spec. Ser.	Low—50-60%	Constant	Close—4-6%	125—150%	For special service, constant load. For fans, centrifugal pumps, crushers, motor generator sets. Simple control.
High resistance rotor	Spec. Ser.	Heavy—175-200%	Constant	Wide—10-15%	175-200%	For intermittent special service duty. For elevators, cranes, conveyors, valves, balers, car pullers.
High Slip, Sq. Cage	Spec. Ser.	Heavy—200-250%	Constant	Wide—8-12%	175-250%	Especially desirable for use with flywheels to care for high peak loads which occur less than 25 times per min. Laundry washers, power hammers, punches, shears.
Multi Speed						
Variable torque	Spec. Ser.	Medium—150%	Adjustable	Close—4-6% for each speed	175—200%	Full load rated torque varies directly with speed. Speed independent of load. For fans.
Constant torque	Spec. Ser.	Medium—150%	Adjustable	Close—4-6%	175—200%	Allowable rating varies directly with speed. Speed independent of load. For blowers, pumps, elevators, cranes, conveyors, stokers, pulverizers.
Constant H.P.	Spec. Ser.	Medium—150%	Adjustable	Close—4-6%	175—200%	Same rated hp. for all speeds. For machine tools.
Wound Rotor	Spec. Ser.	Heavy—200-250%	Constant or Adjustable	Wide—depends on load	175-250%	Used with proper type of control where frequent and heavy starting is required or where low starting current is imperative or where varying speed is desired. For compressors, pumps (displacement), cranes, conveyors, crushers, pulverizers.
Commutator, brush shifting	Spec. Ser.	Heavy—150-200%	Variable	Wide—10-30%	150-200%	High first cost. Excellent speed control. For fans, compressors, pumps.
Synchronous						
Standard	Gen. Pur.	Medium—80-125%	Constant	None	175-250%	May be applied, 1. Where maximum possible operating efficiency is desired for steady continuous loads of 75 hp. and larger. 2. Where exact speeds must be obtained. 3. Where motor speeds of less than 500 r.p.m. are required in sizes 20 hp. and larger. 4. Where power factor improvement is desired. For fans, compressors, pumps, motor generator sets.
Fynn Weichsel Type	Spec. Ser.	Heavy—250%	Constant	None except for short intervals	250%	Starts as a wound rotor induction motor. Runs as synchronous motor. May be operated at speeds below normal for short periods of time. Gives leading power factor, 87-92% at full load and 40-60% at no load. Can be used as synchronous condenser. Self excited.
Single Phase, Alternating Current						
Repulsion ind.	Gen. Pur.	Very Heavy—225-300%	Constant	Close—4-6%	150-175%	Low starting current, high starting torque. These motors start as repulsion motors and when up to speed a centrifugal device short circuits the commutator segments making it an induction motor. For fans, blowers, compressors, pumps, conveyors, stokers. A good general purpose motor.
Split phase ind.	Gen. Pur.	Heavy—150-200%	Constant	Close—5-7½%	150-175%	Infrequent start. Steady loads. Made only in the fractional horsepower sizes up to ½ hp. For fans, compressors, pumps, stokers.
Capacitor ind.	Gen. Pur.	Medium—150%	Constant	Close—4-5%	125-150%	Quiet operating. High power factor. There is also available a high starting torque type which will develop from 200 to 350 per cent of their rated torque at starting. For fans, blowers, compressors, pumps, machine tools, conveyors, stokers.
Repulsion	Spec. Ser.	Heavy—250-300%	Variable	Wide—depends on load		For loads involving heavy starting torque, sudden overloads, printing presses, fans and blowers.
Series	Gen. Pur.	Very Heavy		Wide—depends on load	Limited by commutation	Finds its widest application in fractional horsepower services for fans, appliances and small drills.

Electrical Waves In Slow Motion

THOSE WHO have difficulty in visualizing transient electrical phenomena will appreciate the ingenious device shown in the photographs on this page and on page —of this same issue. It is an apparatus designed and built by C. F. Wagner, electrical engineer in the central station division of the Westinghouse Co. to demonstrate the action of traveling waves on transmission lines. By substituting metal arms, springs and damping resistance elements for the electrical elements, inductance, capacity and resistance, he can demonstrate the behavior of a surge and prolong its life from one ten thousandth of a second to as much as five or ten seconds.

Resembling a streamlined xylophone, the "wave demonstrator" consists of 56 long narrow aluminum arms, pivoted at their center of gravity on hardened steel bearings. A flat spring is mounted rigidly to each of the arms at a point close to the bearing with its free end extending towards the rear of the arm. The free end of each spring is fastened to an adjacent arm. When the first arm is moved up or down it transmits the movement successively to all the other arms in the form of a wave just as a long rope can be made to move in waves when it is snapped at one end.

As long as all 56 arms are allowed to move freely a wave started at one end will move forward to the other end and depending upon conditions at the end, will return. The reflections which occur at the end of a transmission line when a wave impinges upon it are rather interesting. The first case to be considered is that of an open line. On the model this corresponds to permitting the end arm to move freely. When the wave propagates along the line in this case the reflected wave is of like polarity, that is, a wave of the same polarity and same wave shape is reflected. Another interesting fact to observe is that the maximum voltage at the end of the line is equal to twice the maximum value of the oncoming wave. The condition of a short circuited line is simulated by restraining the end arm from moving. In this case, the reflected wave is of like form but of opposite polarity to the oncoming wave.

Positive and Negative Reflection Obtained

With the open-circuited and short-circuited line there is obtained a positive and negative reflection, respectively, of the same wave shape. It should be possible in some way to obtain a condition half way between in which the reflected wave is zero. In an actual line this is accomplished by simply shunting the end of the line with a resistance of a particular value. A resistance is represented in the mechanical analogue by means of a damping element of the squirrel cage motor type. With this connected to the model and set for the critical value it is found that the reflected wave is zero. The oncoming wave upon reaching the end of the line just vanishes with the appearance of being drawn into a vacuum. Demonstrations with different wave shapes verify this observation. When the damping element is set for greater damping the short circuit condition is approached and a negative reflected wave of the same shape but of smaller magnitude is

produced. Similarly, if the damping element is set for smaller damping, a positive reflected wave results.

Damping Device Is Used

The bearings of the arms were made as frictionless as possible in order to eliminate as much of the damping as possible. This effort corresponds to simulating a line with a very low shunt resistance. As already explained for some of the other demonstrations it is desirable to introduce the effect of lumped resistances connected in shunt to the line. One way of accomplishing this result is to introduce a mechanical device, such as a cylinder rotating in oil, as a damping device. In this application it was preferable to use a squirrel cage induction motor whose stator winding is excited by direct current. In such device the eddy currents in the rotor produce a torque on the shaft which is proportional to its angular velocity. The motion of one of the arms of the model is transmitted to the rotor of the motor by means of a system of strings around a wheel attached to the rotor. The effect of different resistances in the electrical system is obtained very simply by merely varying the current in the stator winding.

Long Line Acts as Resistance

It is clear that if there were an infinitely large number of elements of the same kind connected to the end of the model, the device would act like an infinitely long line. At no point would there be a reflected wave. Since there is no reflected wave when a resistance having the critical value is connected to the line, it follows that the infinitely long line connected to our model must act in all respects as a resistance. Since a current flows in the resistance proportional to the voltage, it follows immediately that a current wave proportional to the voltage wave must flow in the transmission line. This is a relation fundamental to all wave theory, but whereas it is usually proved through the recourse of mathematics, the same result was reached by means of the demonstrations and a few simple deductions. In the wave propagation theory, this critical resistance is given a special name, the "surge impedance" of the line.

Job evaluation, seniority and lay offs. Employment guarantees.

Management Board Planning

TWO AXIOMS are assumed: That the important starting point for good public relations is good personnel relations within the organization; and that a management board, on which employes, both office and shop have elected representatives is a logical method of handling management policies.

Then arises the question, What are the most important subjects for the board to deal with in order to promote and preserve understanding of company policies by and harmonious relations with the workers of the organization? What points are of greatest interest to employes?

Results of various surveys to determine the value set by workers on various company policies seem to indicate that job security with assurance of provision for old age is of first importance. Cooperation of management and executives, especially of foremen and superintendents, in bettering one's work, gaining promotion and investigating grievances is a second point. Good working conditions, pay increases when deserved and welfare activities follow in the order given.

Popularity of Social Security activities of the Government is evidence of the interest in job and retirement security but even a casual consideration of the provisions of the laws shows that these can never be adequate for the purpose intended, as unemployment benefits can cover only short periods and retirement benefits will be insufficient to give comfort in old age. The intent of the laws is good, and properly administered they will be helpful, but they can never take the place of job and retirement security wisely administered by the management of each industrial organization to meet its individual conditions.

As a first step, personnel executives seem to agree on job evaluation; determination of the importance and rating of each job and of what is a fair rate of pay. The purposes are to establish equal pay for jobs of equal importance and which require equal abilities, so as to pay what each job is worth; to give proper basis for assignment of workers to jobs and a fair basis for promotion; to improve employe morale so as to get and keep desirable workers; to make jobs desirable and reduce labor turnover.

Factors to be considered and discussed in rating a job are:

1. Education, including training either formal or informal.
2. Skill, covering time and experience to fit a worker for the job.
3. Initiative required, to go ahead independently of detailed instructions.
4. Responsibility for equipment, safety of worker and others, operation of machinery and inspection of product.
5. Mental effort, requiring attention in operations and understanding of directions and processes.
6. Physical effort as to diligence and speed.
7. Hazards in surroundings and in doing the work.
8. Working conditions such as discomforts and inconveniences inherent in the job.

The point system of evaluation is most used and consists in giving to each of the above factors a definite number of points for maximum requirements. For any job the number of points assigned on each factor is according to the requirements of that job. The sum of points for all factors determine the rating of the job, and the rate of pay is related to the rating.

In determining the points to be assigned for each factor, the management board should discuss rankings with employes' representatives and compare similar jobs in various departments to ensure proper relative values. The point scale used by three organizations is shown by Table I.

Table I. The point scales used by three organizations for job evaluation

	N.E.M.A.					Wesths. El. & Mfg. Co.	General Elec. Co.
	1	2	3	4	5		
1. Education	14	28	42	56	70	100	100
2. Skill	22	44	66	88	110	100	400
3. Initiative	14	28	42	56	70	125	
4. Responsibility	20	30	60	60	100	75	100
5. Mental effort	5	10	15	20	25	40	50
6. Physical effort	10	20	30	40	50	40	50
7. Hazards	5	10	15	20	25		
8. Working cond'ns.	10	20	30	40	50	20	100
			Total.....		500	500	800

For the National Electrical Mfrs. Ass'n., ten job grades are established for men and five grades for women and boys. Assignment of points for each factor is to one of the five listings shown above and the total of points determines the job grade. The points, grades and the hourly wage rate in one plant is as shown by Table II.

The base rate is established on a basis comparative with wages in neighboring plants and inequalities in pay for jobs of similar rating are corrected.

Various job grade divisions are in use, the American Rolling Mill Co. using 18 grades and Goodyear Tire and Rubber Co. using three. Daily basic rate of the A.R.M. Co. is $3.50 a day for the first or lowest grades, rising to $12.77 a day for the 18th or highest grade, rise in rate being slower for the lower than for the higher grades. Actually, the rates paid for various grades of jobs in four plants are some 15 per cent above the basic rates.

Where unions are involved, the rate for each job must of course be equal to or greater than the union scale, but the job grading establishes equivalent pay for all jobs of like difficulty and established rate of pay increase with promotion to a higher grade job.

Employee Relations and Company Information

In this connection, it is desirable to convey to the workers of the organization quite complete information as to the relation of wage and other expenses to the income of the company and some companies have adopted plans for profit sharing by either a cash bonus at regular intervals based on profits of the preceding period or a plan of stock sale to workers, the company paying some percentage toward the price of the stock. Unless the workers are given facts, seldom do they appreciate that a major part of the expenses are for workers' wages, and how small a part goes to management and owners.

As an example, in a discussion about cost of management, it was brought out that if salaries of top ranking officials were all distributed to workers, each worker would receive 2 cents a day additional, whereas guesses had been that each would receive $5 to $15 a week additional. For each worker the cost of the services of the successful management of General Motors Co., which gave him his job, was 2 cents a day.

With wage payment established on a scientific basis and as large as is justifiable, the question of job security is more easily solved, but the matter of seniority may give some headaches. When depressions and slack business come, a full prosperity organization cannot be maintained yet laying off men strictly according to length of service may threaten disruption of the organization because of keeping less efficient men, too large a proportion of elderly workers, and the difficulty of training men for transfer to work different from that to which they are accustomed.

It is wise, therefore, for the management board to define seniority rights and procedure in case of necessary layoffs.

Advantages of Established Procedure

Most important factors are length of service, (in one department or in the organization) and ability. Other considerations are physical condition, family responsibilities, place of residence, ease of transfer to other work. Obviously there must be no discrimination on account of union or social activities, so long as there is no offense against company interests; also no discrimination for younger men against older, where ability and availability are equal. In establishing rules for layoff, the employe representatives in management should have full participation and should be encouraged to present the problems to workers and get their views. Differences will arise between executives and workers as to merits of length of service and ability of individuals in determining procedure, but if rules are established and provision made for reference of questionable cases to a layoff committee composed of executives and workers representatives, action, when the need of it arises, should be simplified.

Table II. With the point system the hourly wage bears a definite relation to the rating of the job. The figures below show this relation for one plant which uses the N. E. M. A. system with 10 job grades for men and five grades for women and boys

Points for job	Men's Grades	Women's Grades	Average hourly rate dollars
360—381	1		0.95—1.00
338—359	2		0.90—0.95
316—337	3		0.87—0.90
294—315	4		0.84—0.87
272—293	5		0.82—0.84
250—271	6		0.78—0.82
228—249	7		0.74—0.78
206—227	8	21	0.71—0.74
184—205	9	22	0.67—0.71
162—183	10	23	0.65—0.67
140—161		24	
to 139		25	

As to job security, the tendency is to seek guarantee of yearly income as against high hourly wages. Care must be exercised in working out any such plan that it will not become too expensive during bad years, but to be effective, it must give reasonable assurance of employment for a major part of the year, or of a reasonable yearly income.

Government unemployment has, in some instances, nullified plans that had been inaugurated, because of the expense involved in unemployment taxes. Yet even the most demanding labor leaders are striving for a determinate yearly wage as against a high hourly

wage and uncertainty of employment. If a certain minimum yearly time of employment is insured, it may involve stocking product during dull seasons for delivery later and brings the risk of heavy investment in stock and of change in demand. If yearly income is guaranteed, any pay not earned in slack periods must be earned by extra work in good periods.

In the Hormel plan, sales for a year ahead are estimated, also the work required to produce the goods on the basis of a 40-hr. week, a day's work being a certain amount of goods produced, regardless of the hours worked. Each department is then given each week the amount estimated to produce its weekly schedule. If work is light, the pay for hours not worked is considered as borrowed from the company. When work is heavy, unearned pay is paid back by extra work. Workers are shifted to maintenance so far as possible, to avoid accumulating too much borrowed hourly pay. Repayment of hours may be made any time during a 3-yr. period and at the end of that period any amount due for prepaid work is written off.

Nunn-Bush Co. guarantees to workers a certain per cent of the gross income of the company. Income and payroll for the year are estimated and divided into 52 parts. If at the end of the year, income has exceeded the estimate, the per cent surplus due workers is paid as a bonus. If income is less than estimated, wages are accordingly reduced for the next year.

Procter & Gamble guarantees, after a worker has worked 24 mo., that he will have forty-eight 40-hr. weeks of work a year. Workers may be shifted to other work but at the same hourly rate.

For a worker who has been employed 6 mo. and whose pay is at a rate under $6000 a year, Wm. Wrigley Jr. Co. gives a contract for 35 hr. work a week at a stated hourly rate. He may be laid off, but gets a lay off benefit of 20 to 80 per cent of his base rate for 16 to 28 wk., depending on his length of service. For low hourly rates, the per cent of base rate is larger than for higher hourly rates. Employes may be transferred to other than their regular jobs. Benefits stop if a man gets other work.

When considering any guarantee plan it is wise to go slow, to consult workers as to their preferences and suggestions, and to be quite certain that any plan adopted avoids excessive cost in slack periods.

Other subjects for the management board will be discussed in a later issue of POWER PLANT ENGINEERING.

Air Heater and Economizer Selection

Continued from Page 775

the larger heat trap, and conversely, the heat transfer rate is increased for the smaller unit. The heating surfaces listed in Table V would, therefore, be fictitious values in that the surface listed would be too large for the smaller units and too small for the larger units.

Deterioration of heat traps due to corrosion and corrective measures to reduce maintenance costs is important enough to warrant a bit more space. Prolonging the life of an economizer or air heater is dependent chiefly on preventing active corrosion of the heating surface. Corrosion on the gas side, of course, is due to either SO_2 or high moisture in the flue gases or both. High moisture means oxidation or just plain rust; SO_2 means acid and corrosion when it condenses on a tube or plate of steel. Reduction of active corrosion is accomplished by maintaining tube temperatures high.

In the case of an economizer, the metal temperature is approximately equal to the water temperature in the tube. It is more or less independent of the surrounding flue gas temperature, so the only control in maintaining high tube temperatures is the feedwater temperature. If fuels having high sulphur, high moisture, or hydrogen contents are used, it is best to follow the manufacturer's recommendation on what minimum feedwater temperature should be used in preventing active corrosion and frequent tube replacements.

The air heater is somewhat more flexible in this respect, inasmuch as the rate of heat transfer from gas to air is dependent on both the gas transfer rate and the air transfer rate. In other words, the higher the air transfer rate, the more heat is drawn from the metal and the lower the metal temperature is. Conversely, the lower the air transfer rate, the more the heat is stored in the metal from the hot gases, and the higher the metal temperature becomes. Tubular type air heaters can be designed having inherently high metal temperatures based on this very fact. It is known that gases flowing across and perpendicular to a row of tubes have higher heat transfer rates than gases flowing inside the tubes. To design a tubular heater for inherently high metal temperature, it is merely necessary to allow the air to flow inside the tubes and the gases to flow outside and perpendicular to the tubes.

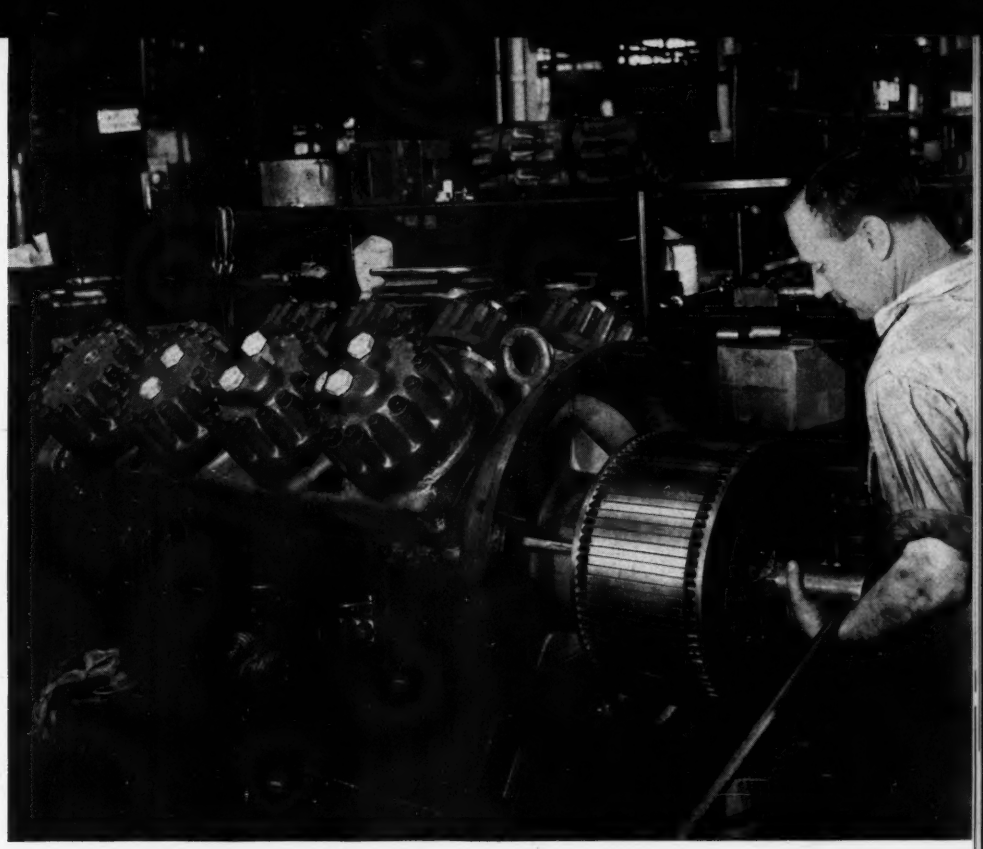
Plate type air heaters can obtain a similar result by reducing the gas flow area and increasing the air flow area by correct spacing of the plate elements.

Regenerative type heaters take care of the high corrosion fuels by offering a unit consisting of two heating element sections such that the element where the cold air enters is removable, and is replaced with a new element when necessary. In all air heaters, when active corrosion occurs, it does so in the region where the cold air enters the unit.

Other methods of reducing corrosion consist of recirculating some of the hot air from the air heater outlet, thus raising the air temperature entering the unit and the metal temperature; and by passing some of the cold air around the air heater, thus reducing air transfer rate. This is done, usually at the low loads only where the tube temperature is low enough to result in active corrosion. Both these methods, however, have the disadvantages of requiring some sort of controls either manual or automatic, and of reducing the availability, hence the efficiency, of the air heater.

With regard to internal corrosion of economizer tubes, it is advisable to have an available feedwater temperature of not less than 212 deg. F. from an open feedwater heater. If the water is not heated to the boiling point before entering the economizer, the water is not thoroughly de-aerated. In other words, it still carries dissolved oxygen which upon being carried into the economizer, is released as the temperature increases and attacks the inside walls of the tubes.

As a conclusion to this series on selection of heat traps a word of advice is appropriate, "Don't pay for hot air and hot water unless it pays for you."



Shop photograph showing the general arrangement of the compressor and drive. The motor rotor is overhung from the main crankshaft and the motor is cooled by the suction gas on its way to the compressor. Each head covers two cylinders, the internal arrangement being indicated by the spares on the shelf at the left of the mechanic's head

Streamlined Air Conditioning

TYPICAL of the advanced trend toward functional design of machinery, the new 100 t. Westinghouse air conditioning unit is a complete answer to the modern air conditioning problem and carries into process and commercial fields the self-contained, hermetically sealed construction so successfully applied to the domestic refrigerator. It even goes a step farther in that the motor arrangement and design is such that external ventilation is not necessary, thus automatically removing one factor which heretofore has placed restrictions in the installation and location of air conditioning units.

Furthermore, the new unit sets a new standard for space and weight so that it fits readily into small corners and requires no special foundation. Nominally rated 100 t. at 1150 r.p.m., the unit has a capacity of 1,212,000 B.t.u. per hr., based on 37 lb. per sq. in. ga. suction pressure, 65 deg. F. suction temperature with cooling water in at 75 deg. F. and out at 95 deg. F. The compressor alone weighs 4200 lb. and the approximate overall dimensions are: length, 90 in.; width, 34 in.; and height, 36 in. The complete unit, compressor and condenser weighs 8100 lb. and the corresponding dimensions are 96, 34 and 70 in. This is said to be about ⅔ smaller and ½ lighter than the conventional compressor while 7 yr. development of reed type valves and suction gas manifolds is reported to have added about 12 per cent to the efficiency over previous totally enclosed designs.

Engineered as a complete unit, the design is predicated upon easy installation, trouble proof operation and low maintenance. The compressor and motor mounted on a common shaft eliminates the problem of "lining up," power losses involved with transmission devices, and, more important, makes it possible to have a hermetically sealed unit permanently free from dust, dirt and moisture in the working parts. Complete pressure lubrication is provided by an oil pump, reversible so as to prevent trouble through inadvertent phase reversal of the electrical connections.

The hermetic seal is made possible by eliminating a stuffing box or seal of any kind around the shaft. Suction gas from the evaporator enters the end bell of the motor at the centerline. From here it passes by means of cored holes in the rotor and stator, through the motor to the crankcase of the compressor and then by short direct passages directly to the suction valves.

The compressor is of the V-type with 16 cylinders of 3 in. bore and 4½ in. stroke. Suction and discharge valves are of the automatic operating reed type and arranged with the four valve groups for two cylinders in a single cylinder head as shown above. This gives the compressor the appearance of a conventional 8 cyl. V type compressor or engine.

The 100-hp., 1150 r.p.m. driving motor is totally enclosed, gaseous refrigerant cooled, with the rotor mounted on the crankshaft extension. The motor current is low, for 220 volts 60 cycle only 926 amp., on 208 volts only 875 amp. locked rotor. The unit is designed for simple magnetic "across the line" starting with thermal overload protection. Starting current may be limited, however, to any value to suit local condition by using conventional step starters.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

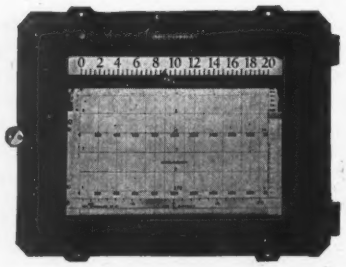
Diesel Instruments

PIEZO-RAY is the trade name selected by the Commercial Engineering Laboratories, 4612 Woodward Ave., Detroit, Mich., to designate a group of related instruments including Cathode Ray Oscillographs and Piezo-Electric Crystals. The major application of this equipment is to the study of the pressures and torsional vibrations of internal combustion engines. The units, singly and in various combinations, have literally hundreds of other industrial applications.

There have been over four years of continuous progress in the development of this equipment. The group includes standard RCA and CEL units carefully balanced to secure the highest possible operating efficiency. The company has had the full cooperation of the RCA engineers and other nationally known authorities on electronics. The complete line is described and illustrated in a new bulletin "Balanced Unit Piezo-Ray Equipment."

Two New Controllers

AN ECONOMICAL means for obtaining accurate control of electric furnaces and ovens without the use of rheostats, transformers or other expensive equipment, is said to be provided in a new recorder-controller for electric heat recently developed by the C. J. Tagliabue Mfg. Co.,



Park & Nostrand Aves., Brooklyn, N. Y. The instrument (shown by the illustration) has no measurable controller "dead zone" and will hold a steady temperature instead of the oscillating temperature of "on-off" or two-position control. The operation and mechanical construction of the new recorder-controller is similar to the company's familiar line of potentiometers with the exception that by reciprocating the control contacts throttling regulation of electric heat is obtained.

The company also announces the development of a new indicating potentiometer controller of the self-balancing type, which has many industrial applications for regulating temperature, hydrogen ion, etc. The instrument is designed to indicate temperature at all times on a 10 in. scale. The control point is adjusted by means of a knob to permit a comparison between the control setting point and the temperature indicator.

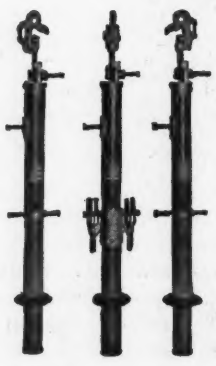
Like all other models of the Celectray potentiometer line, this instrument utilizes a beam of light, a mirror galvanometer and a phototube, which eliminates the use of a complicated mechanical design and allows for a unit constructional design where there is no motion unless the temperature is changing. A special arrangement of lighting the scale is accomplished by using a Lucite rod that carries the illumination from the same source of light that is used to determine the galvanometer position.

Portable Varmeter

WITHOUT extensive wiring, expensive equipment, or cutting into the line, the new General Electric portable varmeter permits quick determination of current up to 300 amp., of line volts, and of reactive kv-a. on power lines. The new varmeter is simple to operate and a lineman can clamp the 12-pound instrument on the line, connect the voltage dividers, and obtain readings of volts, amperes and vars by the operation of a selector switch. Scale illumination assures accurate readings in poor light or at night.

The Type AE-1 instrument employs an electrostatic watt-meter element and measures vars (reactive volt-amperes) on a single-phase basis by indicating the product of amperes and volts, and the sine of the angle between these quantities. The jaws of a split-core transformer on top of the varmeter may be latched open, the instrument hung on the line, and the latch tripped with an insulated stick. This transformer supplies the element with a voltage proportional to the line current.

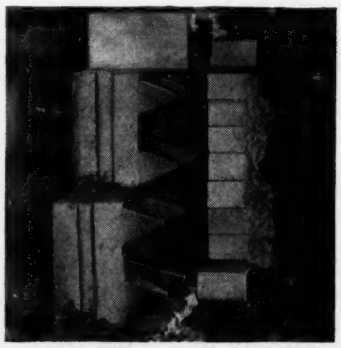
Voltage dividers, which are attached to the line by clamps, supply the definite fraction of line voltage. These dividers, two connected in series for single-phase, and three connected to form a Y box for three-wire, three-phase, consists of plastic tubes containing resistors, a small capacitor, and a neon lamp which glows when the dividers are energized. Connections are made with these dividers by flexible leads with spring connectors.



After connecting the varmeter and dividers to the line, a selector switch may be set at the end of the tube projecting from these instruments. After the range selector switch is set, an adjusting knob on the end of the tube is adjusted until the light beam index shifts from one point to another. The scale is then read and the actual vars, volts, or amperes determined by reference to curves supplied with each set of voltage dividers.

Pyramid Air Cooled Walls

MCLEOD & HENRY CO., INC., Troy, N. Y., announces its Pyramid type air cooled wall for oil or pulverized fuel fired furnaces. It consists of panels of specially designed refractory block, which provide an air space at the rear, and slotted header blocks fitted with cast iron anchors and tie links. Made up of two courses of Pyramid blocks each 10 in. high and one course of slotted header blocks, each panel measures 25 in. in height and interlays perfectly with the standard 9-in. firebrick courses. Each block has a group of pyramids on its rear face increasing the cooling surface area. The continuous circulation of air draws off the objectionable heat conducted through the furnace walls and maintains the fire face of the walls below the point of spalling in oil fired furnaces or below the fusion point of the ash in furnaces fired with pulverized coal. Although the principal advantage in air cooled walls is the saving in refractory maintenance, the preheated air circulating in back of the Pyramid blocks may be routed for delivery back into the furnace by ducts, thereby utilizing the contained heat for increased combustion efficiency.



Choosing Materials for Edward Valves — *No. 11 of a Series*

FINE SCIENTIFIC EQUIPMENT AIDS EDWARD MATERIAL CHOICE

HEAT, not high pressure, supplies the theme for research to govern the choice of valve materials. Corrosion, dread cause of excessive costs and occasional disasters, often surrenders without a struggle if the true nature of the destructive forces can be correlated with newly developed materials. High temperatures, however, still offer wide scope for study. Plastic flow of alloys in almost immeasurably small increments, invisible grain transformation at indeterminate rates, effect of long continued temperature fluctuating at irregular intervals — these suggest roughly the elements with which the valve metallurgist wrestles. Outstandingly fine equipment helps Edward technicians find why materials make valves behave the way they do.

• • •

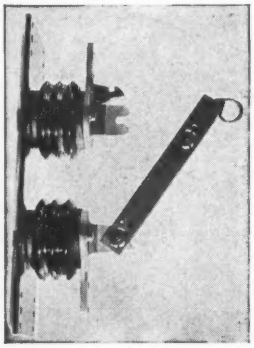
THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO INDIANA

EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

Indoor Disconnecting Switches

A NEW LINE of indoor disconnecting switches for hookstick or group operation has been announced by the Westinghouse Electric and Mfg. Co. The new switches are available in ratings of from 200 to 6000 amp. for 5000-v. service, and in sizes ranging from 400 to 6000 amp. for 7500 to 34,500-v. service.



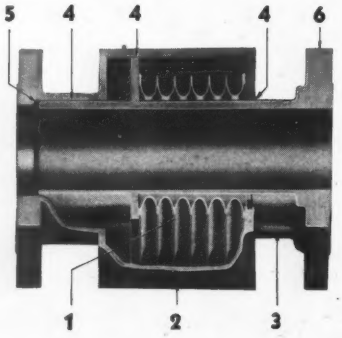
Easy operation and exceptional wearing properties of the contact area or the blades have been achieved by means of a novel multiple-line-pressure area on each blade. This contact consists of 30 silver-coated "sled runners," 0.005 inch wide, on each blade. These line contacts, distributed over two rectangular areas about one-half by three-quarters of an inch, resemble screw threads on a flat surface.

To increase the ease of operating the new switches, the operating eye and blade latch have been designed to produce a cam or pry-out action, which completely disengages the blades from the tongue member. This feature allows the switch to open easily, though it may have been closed for a long time.

Switch blades are made of hard drawn copper of high conductivity, arranged in a parallel-path design, so that during a short circuit the magnetic force between blades increases contact pressure.

Packless Expansion Joint

AN IMPROVED and simplified, compact packless expansion joint for steam and hot water lines known as the ADSCO Packless Expansion Joint, U-Ring Type for low and high pressure and temperature service, is announced by the American District Steam Company, North Tonawanda, N. Y.

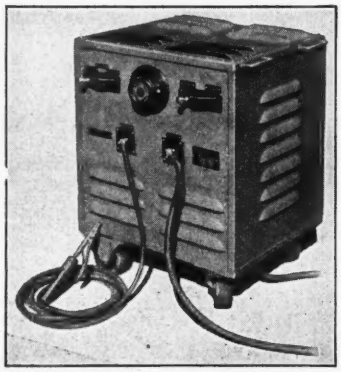


The sectional view illustrates the essential features of the joint which has an expansion element operating on the principle of cold springing used in the installation of pipe bends. The expansion element (1) is a series of welded U-Rings of corrosion resistant steel which is welded to the steel body (2) and the guide (4) on the movable sleeve (3) to form a permanent seal between the stationary body and the movable sleeve. The element is compressed axially or cold sprung one-half of the total traverse for installation in the cold line. As the line expands with the application of heat, the compression in the element is relieved and it passes through the neutral position and into tension for the remaining half of the traverse.

There is a full, unrestricted flow through the joint and the element is fully enclosed in a steel case so that no dirt or scale can enter the element to interfere with its operation. The joint is guided at three points (4) and a limit stop (5) prevents overtravel. It is furnished with flanged ends (6) or with beveled ends for welding for pressures to 300 lb. with traverses of 1, 2, 3 and 4 in. in single joints with or without anchor base.

Low Current Arc Welder

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has introduced a novel design of low-current electronic arc welder for precision work. This Weld-o-tron unit, as it is called, can be used to weld with currents as low as 5 amp., using newly developed 1/32 in. and 3/64 in. electrodes. Steels, stainless



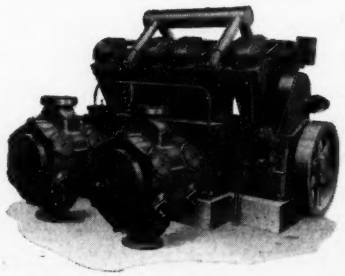
steels, and other metals lighter than approximately 18 gage which ordinarily could not be welded satisfactorily without seriously burning the metal and destroying many of its vital properties, can readily be welded with this unit. Sheets as thin as 0.010", or approximately 32 gage, can be handled without any difficulty.

The heart of the portable Weld-o-tron electronic arc welder is a multiple tube polyphase mercury vapor rectifier unit. It makes use of the newest type of rectifier tubes, specially developed for this equipment. The unit combines light weight, long life, and absence of rotating parts with the advantages of both a-c and d-c arc welding. The readily accessible controls and terminals are of the dead front type, and are located on the control panel. Two of them are simple two-way switches, one for current range selection, the other for reversing polarity of the tube terminals. A hand wheel, with easily readable dial, provides fine adjustment of the welding current. The unit is designed with a constant current characteristic which makes the arc easy to start, easy to hold and which produces the optimum heat conditions at the weld. The same characteristics are obtained from minimum to maximum current settings.

Gas-Engine Compressor

INGERSOLL-RAND CO., 11 Broadway, New York, N. Y., announces a new heavy-duty, gas powered compressor built in 485 and 650 hp. sizes using 6 or 8 V-type power cylinders and supplied with suitable cylinders for pressures up to 5000 lb. and for vacuum service. By using only two compressor frames on either size, the inlet, discharge and inter-stage piping and manifolding are simplified, and only two stuffing boxes are required.

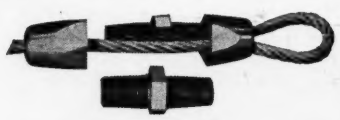
This LVG compressor incorporates overhead valves and removable wet-type



liners in the power cylinders. All auxiliaries, including the camshaft, the built-in recirculating water pump and the auxiliary power take-off are driven from the flywheel end of the shaft, a feature which promotes good governing and smooth operation. Lubrication is full force-feed with continuous oil cooling and oil filtration. Power pistons have oil-cooled crowns. Governing provides for manual or automatic control down to half speed.

Wire Rope Clamp

NATIONAL PRODUCTION CO., Detroit, Mich., announces the new Safe-Line Wire Rope Clamp which leaves no sharp wire ends nor projections to injure men who work with it.



Unlike a spliced joint or zinced-in socket, a joint made with this clamp can be quickly readjusted to the proper tension without additional expense, and it can be used over and over again. The inner surface that grips the wire rope is double spiral splined to fit each strand and wire of the rope, thus making a perfect and secure grip on each section. The gripping halves of the clamp are held tightly to the rope by taper threaded nuts. The clamp is made of high tensile strength steel and is guaranteed to outpull any wire rope made. Stock sizes are for ropes ½ to ¾ in.

Savings!

TREATMENT COSTS NOW $500.00 A YEAR LOWER

ABILITY of Nalco to increase the efficiency of existing softening plants has been demonstrated time after time. One of the most recent reports coming in from the field credits Nalco with a saving totalling $500.00 a year.

WATER BILLS CUT $150.00 PER MONTH

BECAUSE Nalco treatment has enabled them to operate successfully with water from their own well for boiler make-up, one company reports a saving of $150.00 a month on water bills. This is typical of Nalco's ability to get good results with any water.

SAVES $5,000.00 ON BOILER MAINTENANCE

SOME PLANTS keep complete records on all items that go to make up operating costs. It was in one such plant that Nalco was credited with a saving in boiler plant maintenance costs of $5,000.00 in the first year.

INCREASE IN EQUIPMENT CAPACITY WORTH $1,250

LAST YEAR the engineer in a prominent plant was just about ready to spend $1,250.00 for increased facilities for reducing the temperature of cooling water. Then he heard about Nalco Stabilizing Treatment. With scale prevented by Nalco, heat transfer jumped up and there was no need for more equipment.

YOU have heard about the ability of Nalco to stop trouble and improve performance, but cutting costs is one of the major aims of Nalco engineers. That's why you can hardly afford to not know what Nalco offers. We will be glad to tell you without obligating you in any way. Call or write.

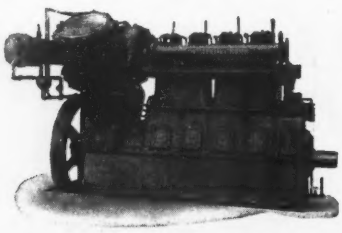
NATIONAL ALUMINATE CORPORATION
6224 W. 66th Place **Chicago, Illinois**

Inquiries other than domestic, except those from U. S. Possessions, Canada and Mexico should be addressed to ALFLOC, LTD., Bush House, Aldwych, London, W.C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS, LTD., 372 Bay St., Toronto, Ont.

THE NALCO SYSTEM OF FEEDWATER TREATMENT

Diesel Driven Compressors

CHICAGO PNEUMATIC TOOL CO., 6 East 44th St., New York city, announces a recent development in Class W-CO Stationary Diesel-driven compressors consisting of a double acting water cooled compressor on a common crankshaft and base with a Chicago Pneumatic heavy-duty Diesel engine. Standard sizes of the two-stage compressor are available in capacities of from 662 to 2000 c.f.m. for pressures of from 80 to 125 lb. Other sizes and types are available for



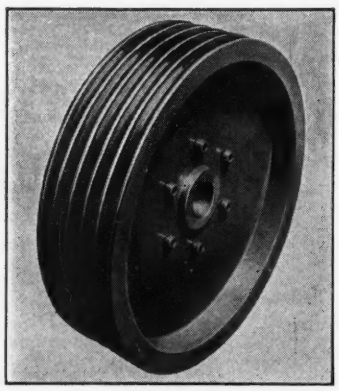
lower and higher pressures. The engine is of the heavy-duty, medium speed, high compression full Diesel type with the Bosch system of solid injection. It has full pressure lubrication, adjustable shell type, babbitt-lined bearings and removable cylinder liners. Quick starting is provided by air starting valves that admit air to all cylinders. The compressor is of the V type, with a stuffing box for each frame neck, arranged to prevent oil from being carried along the piston rod. Cylinders are of the double acting, water cooled type with Simplate Valves and liberal water jackets extending around the valves to give a maximum cooling effect. Cylinders are made of semi-steel and have walls of sufficient thickness to permit two reborings. Air pistons are of the hollow-box, light-weight design, fitted with two concentric rings. Two stage units are regularly supplied with an intercooler and with either three or five step air control.

Steam Atomizing Type Desuperheater

REPUBLIC FLOW METERS CO., 2224 Diversey Parkway, Chicago, Ill., offers a new steam atomizing type desuperheater designed to give complete atomization of desuperheating water at all flows by the impact of a small quantity of high pressure steam at constant velocity and thus to provide a complete range of operation from zero to maximum. It is designed to be mounted in any plane in any horizontal or vertical line, to require little space, to be readily removable from the line and to produce zero pressure loss. Desuperheating water, usually low pressure feedwater, is controlled by a temperature controller to maintain constant down stream temperature. Atomizing steam is taken from a high pressure system or, if a reducing valve is installed, from above the reducing valve. The regulator controlling this valve may also control automatic shutoff valves in both atomizing steam and desuperheating water lines. The desuperheater is built in two standard sizes for any steam capacity and for any pressure and temperature conditions up to and including 1250 lb., 950 F.

Texrope Drive Demountable Sheaves

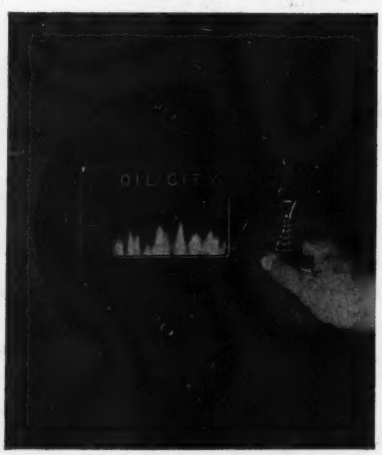
ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has extended its line of Texrope demountable rim type sheaves. These cast iron sheaves all consist of a substantial bushing on which may be mounted a sheave rim of desired number of grooves and pitch diameter. This



demountable rim type of sheave was originally introduced primarily for use on oil field equipment. Since this type provides an easy method for changing sheaves without removing the hub from the shaft, however, it can be used to advantage for any application requiring a limited number of fixed steps in speed change.

Fire Observer With Pyrex Glass

MADE by the Oil City Tank & Boiler Co., Oil City, Pa., Oil City Fire Observer is used for the purpose of inspecting the fuel bed, furnace walls, and tubes without admitting cold air into furnace. It has a wide opening or port covered, on the inside of the shutter,



so all infiltration of air eliminated. When the shutter is raised, the port is opened and the colored Pyrex glass on the outside diffuses the glare and permits a safe, clear vision of the furnace. When the handle is released, the cover entirely closes the port. The fire observer is equipped with a Monel metal screen inserted in back of the lens, to protect it when the shutter is opened.

Automatic Storage Control

A NEW dust-tight type, explosion proof design of the TELLEVEL described and illustrated on page 84 of the January, 1939, issue has been announced by Stephens-Adamson Mfg. Co., Aurora, Ill. This consists of a multiple electrode sealed mercury switch so mounted that tipping it in any direction will break the electric current. A polished aluminum bell provides the dust-tight housing for the switch and electric wiring. Mounting for the mercury switch is a fiber holder, screwed to the top of the tipping rod. This rod is pivoted in a rubber diaphragm with its lower end fitting into the globular polished aluminum bell. The bell housing is supported on the end of a ½ inch conduit pipe.

The TELLEVEL is control for starting and stopping conveyors feeding bulk materials to bins or hoppers—and for opening and closing valves feeding liquids into tanks.

Operation is normally entirely automatic, but, by a simple change in wiring, the TELLEVEL can be made to keep the flow of material stopped or continuous until the control switch is thrown.

Diactor Generator-Voltage Regulator

GENERAL ELECTRIC has announced new Diactor generator-voltage regulators for use with alternating and direct-current machines. The new regulator, an improved streamlined design of the Type GDA generator-voltage regulator, will be available in six ratings for generators rated 15,000 kw., 3600 r.p.m. and smaller machines at correspondingly lower speeds. The smallest of the Diactor regulators is designed for generators up to 25 kw.

The quick-action, wide-range rheostatic-type regulator contains an improved torque element which eliminates all pivots and bearings. A self-aligning spring suspension precludes all maintenance at this point. A great reduction of

weight in the torque assembly has cut down the inertia providing a smoother regulation curve.

This automatic generator voltage regulation provides increased illumination of lights, more satisfactory operation of heating appliances, and assurance that motors operate in accordance with their design characteristics. The new design, designated Type GDA and GDD for alternating- and direct-current machines, has a totally enclosed case to prevent the entrance of dust and dirt and to improve the appearance of the switchboard.

THE ORIGINAL clip type valve with drain channels and bronze bonnet-thread-bushing . . . . . .

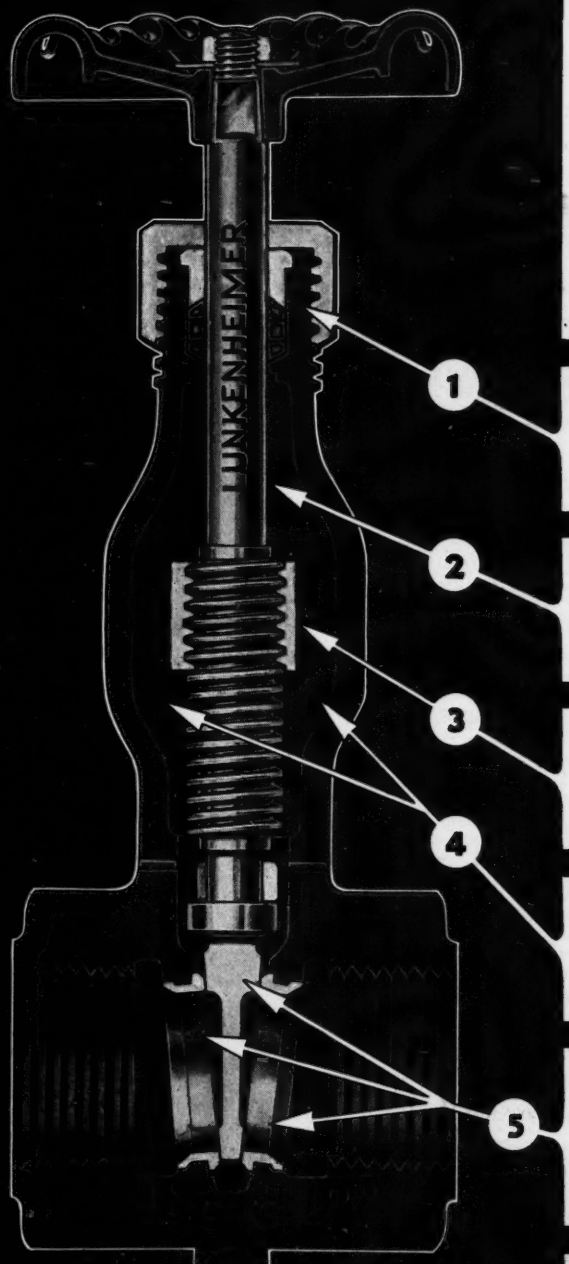


Fig. 1640

LUNKENHEIMER
Fig. 1640
"KING-CLIP"
(The King of Clip Valves)

1 Stuffing Box
Extra strong construction—hexagon head gland.

2 Bronze Stem
Perfectly aligned—repacking seat above stem threads.

3 Bronze Bonnet Bushing—
Cast in. Non-corrodible contact for stem.

4 Drain Channels
Large and unobstructed—ample size to drain bonnet. Will not clog.

5 Bronze Disc and Rolled in Bronze Seat Rings
Bronze to bronze contacts prevent corrosion.

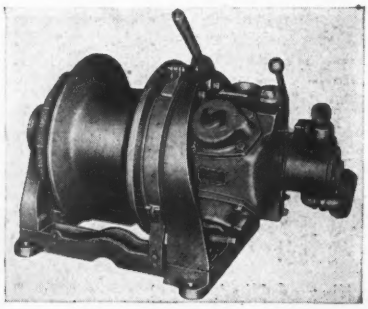
ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST. NEW YORK

CARRIED IN STOCK BY LUNKENHEIMER DISTRIBUTORS

8-81-44

Single Drum Reversible Hoist

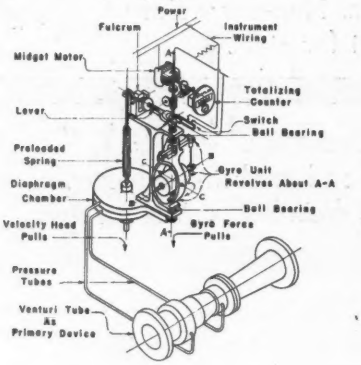
SULLIVAN MACHINERY Co., Michigan City, Ind., announces its Class L-111 reversible Pistonair Single drum hoist which is convenient and economical for both surface and underground application. This hoist is light and compact



and is equipped with large diameter drums for long rope wear, heavy duty Lubriseal ball bearings and four-cylinder reciprocating air motor. It is fully enclosed and can be furnished with either positive or friction-type clutch.

Gyrometer Flow Meter

GYROMETER is the trade name of a new flow meter utilizing the balancing effect of a gyroscopic element acting against pressure differential produced by a Venturi tube, nozzle, orifice or Pitot tube. The meter is suited for flow measurements on lines handling water, air, gas, steam, process and corrosive fluids, sewage or activated sludge with average error at any point in the range within plus or minus 2 per cent.

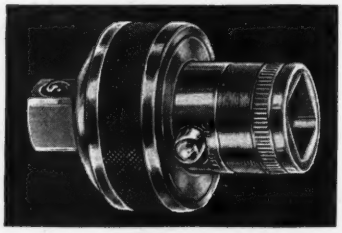


Connection is made by pipe, not greater than 3/8 in., between the two sides of the actuating element in the pipe line and a diaphragm inside the instrument. This diaphragm connects to one side of a lever, the other end of which operates a micro switch, attached to the motor driven gyroscope which opposes the diaphragm pull. With liquid flow varying as the square root of the diaphragm head and motor speed varying as the square root of the gyroscope pull, the angular velocity of the motor to which the counter is geared is in proportion to velocity of flow when the two forces are in balance above the lever fulcrum.

A characteristic of the meter is that the transfer of actuating liquid in the small pressure lines does not exceed ½ cu. in. for maximum meter range. In addition to use of liquid pressure to actuate the meter, the company can supply its air-differential system for application of the meter in measuring flow of liquids unsuited for the connecting pipes or actuating pressure chambers. Simplex Valve and Meter Co., 68th & Upland Sts., Philadelphia, Pa.

Ratcheting Adaptor for 1/2-in. Drive Handles

SNAP-ON TOOLS CORP., Kenosha, Wis., announces a new ratcheting adaptor, a newly developed addition to the socket wrench field. It is a unit that can be used in combination with any standard

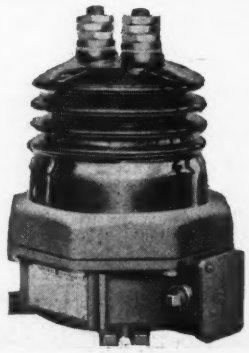


½ in. square drive handle, and, placed in the hook-up between the handle and the socket wrench, it converts the handle into an efficient, speedy ratchet type tool. A convenient thumb button instantly reverses the ratchet action. There is hardly a nut-turning job on which this new unit will not afford greater working convenience and additional wrench speed.

Small Pyranol-Filled Current Transformer

TO MEET the demand for a smaller outdoor current transformer General Electric offers for the first time a 15-kv. Pyranol-filled outdoor current transformer of the porcelain-shell type. The new Type KF-305 transformer is filled with Pyranol, a non-inflammable insulating liquid with high dielectric strength. This insulation will not sludge and provides no fire hazard and it is hermetically sealed.

Adaptable for either horizontal or vertical mounting, the new transformer meets the stringent NEMA accuracy classification of ¼X, ¼Y, ⅛Z, and fills the 4.5-inch impulse test-gap requirements of the ASA. Three coats of Glytal gray paint provide a surface resistant to abrasion. The core and coils are mounted in a shallow cast-iron tank and



extend up into a porcelain housing which acts as a high-voltage bushing. High-voltage terminals are threaded studs mounted on top of the porcelain shell. The secondary terminals are fixed studs inserted in a compartment on the base. These terminals sealed are in glass at the point where they enter the tank. This glass seal affords a liquid-tight construction.

Control Stations

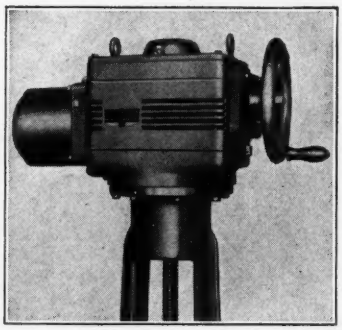
A NEW three-button control station, attractively styled and designed for easy installation and long, trouble-free life, has been placed on the market by the Allen-Bradley Co., 1311 S. First St., Milwaukee, Wis.

This new station is available with various button markings, including "Forward-Reverse-Stop," "Raise-Lower-Stop," "Up-Down-Stop," and "Open-Close-Stop." It can be mounted in either a vertical or horizontal position. Also, it may be provided with a bar for locking the "Stop" button in its open position.

The new three-button Bulletin 800 Control Stations have a maximum d-c rating of 1 ampere, 115 v; 0.5 ampere, 230 v; and 0.25 ampere, 550 v. The maximum a-c rating is 3 amperes, at 110, 220, 440, and 550 v.

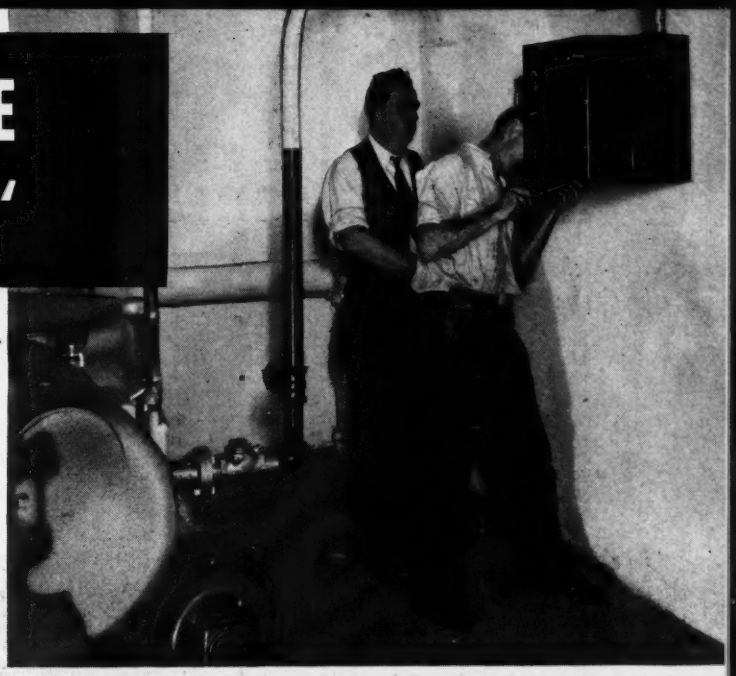
Valve Operating Unit

A NEW valve operating unit intended for electric motor operation of gate and globe valves or sluice gates is announced by Cutler-Hammer, Inc., Milwaukee, Wis. The new C-H Bulletin 816 Valve Operating Unit, providing a controlled thrust action directly on the valve stem, gives a high degree of accuracy in opening and closing the valve. The unit consists essentially of: thrust springs which



compensate for the expansion and contraction of the valve stem resulting from temperature changes and assure a complete and accurate functioning of the valve; high torque, reversible motor, the high speed rotating energy of which unseats the tightest valve; simple jaw clutch for coupling the operator to the yoke nut; gear reduction, oil immersed for complete lubrication; thrust limit switch controls seating of the valve without jamming or damage; position limit switch stops operator in open valve position.

HE REALIZES THE IMPORTANCE OF "IC"



That's Why He's Installing G-E Air Circuit Breakers on All Branch Circuits

BESIDES adequate interrupting capacity ("I C"), G-E air circuit breakers provide overcurrent protection, with adjustable time delay. And you can restore service at once, safely, just by turning a handle. By providing three-phase interruption, single-phasing of motors, with all its harmful effects, is prevented. Because of their trip-free action, these circuit breakers cannot be held closed against short circuits. They are designed for interrupting ratings up to 80,000 amp.

For Main Circuits He Bought G-E Air Circuit Breakers Assembled as a Completely Enclosed Switchboard

This assembly of G-E air circuit breakers is installed as a unit. All you need do is to connect the leads. Being completely dead-front, it offers the advantage of safety over old-fashioned boards that have exposed live parts.

"I C" = Interrupting capacity

THE severity of a short circuit depends largely on the capacity of the transformers that feed the circuits and it can *not* be determined by the normal load on the circuit. As plant loads have grown, transformer capacities have been materially increased. Therefore, short circuits present an ever-increasing hazard. They gravely endanger personnel and property wherever the power supply has outgrown the interrupting capacity ("I C") of the protective devices. Are you sure of your "I C"? With G-E air circuit breakers of *known* interrupting capacity, you *can* be sure.

GENERAL ELECTRIC

890-80

News from the Field

POSTHUMOUS AWARD of the 1940 John Fritz Gold Medal, one of the highest honors in engineering bestowed in the United States, given annually for notable scientific or industrial achievement by a board composed of sixteen representatives of the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers, went to Dr. Clarence Floyd Hirshfeld, who until his death on April 19 of this year was chief of research of the Detroit Edison Co.

COMBUSTION ENGINEERING Co. has extended its departmentation of activities, involving certain reassignments in its organization. The growing importance of the marine field has made necessary increased personnel in the Marine Department and, in view of the particular adaptability of the La Mont steam generator to marine installations, W. H. Armacost has been given the responsibility for engineering development in this department. H. S. Colby has been delegated with executive responsibility for the conduct of the company's marine business. Donald S. Walker has been appointed general sales manager and will be assisted by Otto deLorenzi and H. G. Ebdon, the latter formerly of the New York District Sales Office, as assistant general sales managers.

E. A. BENDING has become associated with the Wm. Bros. Boiler & Mfg. Co. to handle sales promotion and engineering assistance in the water tube boiler and spreader stoker division. He has had a great deal of experience in this field, having worked as chief combustion engineer for the Middle West Utilities Co. and later served some 6 yr. with the Hoffman Combustion Engineering Co.

WALTER P. PAEPCKE, president of the Container Corp. of America, announces plans for improvements in the Corporation's Chicago Ogden Avenue paper mill is estimated at $250,000. A new 75,000 lb. per hr. steam boiler, water treating system and buildings are included in the modernization program, which eventually will be extended to include new turbines and an improved paper making method. Installation of oil burners and a service tank at the Corporation's Philadelphia plant will be made at a cost of $15,000. Water supply improvements for the Company's Circleville, Ohio, strawboard mill will cost $30,000.

UNDER the auspices of A.S.H. & V.E., the sixth International Heating and Ventilating Exposition, will be held January 22 to 26, 1940, in Lakeside Hall, Cleveland, O. Management of the Exposition and all details of exhibit arrangement and leasing will be in charge of the International Exposition Co., Grand Central Palace, New York under the personal direction of Charles F. Roth, Manager.

JAMES L. ASHLEY, secretary and treasurer of The International Nickel Co. of Canada, Ltd., who has been an executive since the formation of the original International Nickel Co. in 1902, has decided to retire from these positions under the company's retirement system. He will continue to serve in an advisory capacity for several months. He remains as a director of The International Nickel Co. of Canada, Ltd., and its various subsidiaries.

William J. Hutchinson was elected to succeed Mr. Ashley as treasurer and also elected a director to fill the vacancy on the board caused by the resignation of William W. Mein. Henry S. Wingate, assistant to the president of the International Nickel Company, Inc., was elected secretary of the parent company.

HEWITT RUBBER CORP. announces the appointment of Wimberly & Thomas Hdwe. Co., Birmingham, Ala.; Machinery & Supplies Company, Kansas City, Mo.; Bitco, Inc., Wallace, Idaho; McChesney-Rand Equipment Co., Albuquerque, N. M.; P. J. Hanns Co., Eugene, Oregon; Texas Belting & Supply Company, Houston, Texas; and C. D. Franke & Co., Inc., Charleston, S. C., as distributors who operate under the exclusive Hewitt Rubber Franchise plan, handling a complete line of industrial rubber goods.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS will hold its 35th annual meeting in Blackstone Hotel, Chicago, January 17 to 19, 1940. Technical sessions will cover Industrial, Domestic-Commercial, and Meat Refrigeration, Corrosion, Refrigeration in Agriculture The second All-Industry Exhibit of Parts Manufacturers Assn. will be held at the same time.

CATERPILLAR TRACTOR Co. has announced the appointment of V. H. (Vic) Wallace as western sales manager to succeed the late H. H. Chambers, with headquarters in San Leandro, California

In 1927, Mr. Wallace became affiliated with Caterpillar's advertising department at San Leandro, and was almost immediately sent to Peoria, Illinois, as assistant advertising manager where he remained for 5½ yr. and in Januray, 1933, was transferred to the Western Sales Division as district representative with headquarters in Los Angeles, then in San Leandro, covering territory as far north as Vancouver, B. C. In 1935, Mr. Wallace was oppointed Agricultural Sales Manager of the Western Division, with headquarters at Spokane, Washington, continuing until November, 1938, when he was transferred to San Leandro as Assistant Sales Manager, which position he held until the present appointment.

THE H. K. FERGUSON Co. of Cleveland and New York, has been awarded the contract for the building of the boiler plant, and installing a 200,000 lb. Ba. & Wi. integral furnace boiler at the Ivorydale, O., plant of The Procter & Gamble Co. It is said that this will be the largest integral furnace boiler for pulverized coal built to date.

APPOINTMENT of Frederick J. Griffiths as executive vice-president in charge of the newly-created Alloy Steel Division of Copperweld Steel Co. was announced by President S. E. Bramer of the company. The appointment follows the earlier announcement by Mr. Bramer that the Copperweld Steel Company has purchased the plant and assets formerly owned by the American Puddled Iron Company at Warren, Ohio. The finishing operations now being carried on in the Copperweld Steel Company's plant at Glassport, Pa., will continue as usual, and Mr. Bramer announces there is no intention of transferring any of the Glassport operations to Warren.

A. J. WADHAMS, Vice President of The International Nickel Co., Inc., and manager of the Development and Research Div. has announced a recent change in the organization set up at the Bayonne (N. J.) Laboratory of the Company. The executive group now includes Dr. N. B. Pilling, Director, Dr. W. A. Wesley, Assistant Director, E. M. Wise, Staff Advisor and D. C. West, Manager.

WILLIAM S. SHIPLEY, president of the York Ice Mach. Corp. reports that during the 5 mo. period from June 1, 1939, to November 1, 1939, orders booked totaled $6,501,499 as compared to $4,576,831 for the same period last year, an increase of 42 per cent. "It is interesting to note," added Mr. Shipley, "that the month of October this year was practically equal to October, 1936, which produced the largest volume of any October in the past nine years."

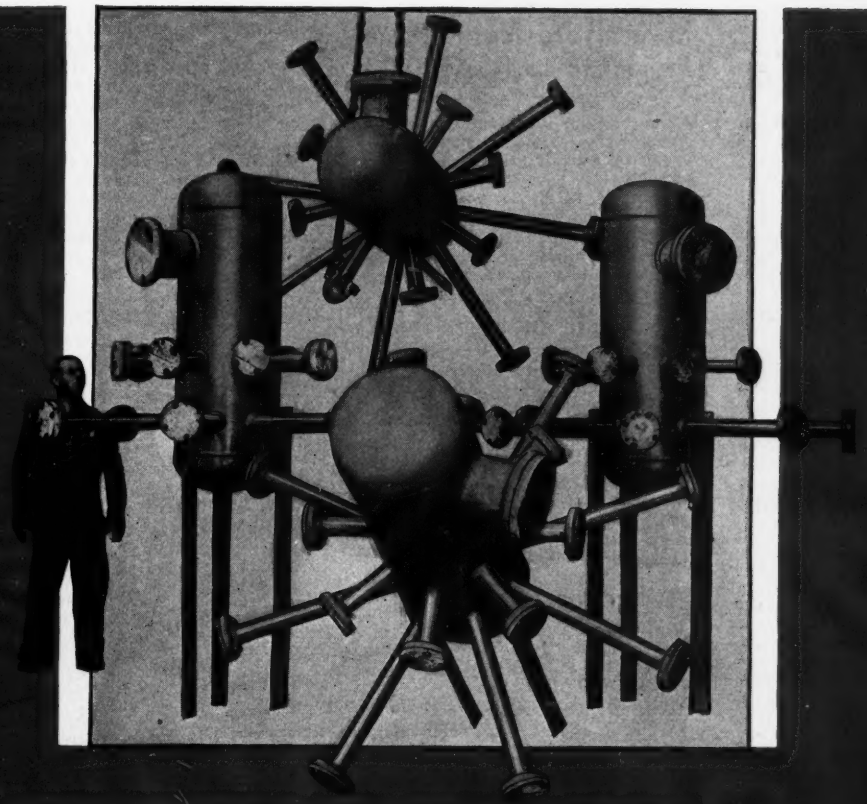
THE NATIONAL BUREAU OF STANDARDS, U. S. Department of Commerce, Washington, D. C., has available Revision of Fuel Oil Standards, CS12-38, covering changes in agreement with the recent revision adopted by the A.S.T.M. D 396-39T. The changes recommended cover principally the lowering of the pour point of No. 1 and No. 2 oils and lowering the viscosity of No. 3 and No. 5 oils.

PRELIMINARY permit for a 5,000,000-hp. hydro-electric development, consisting of 18 projects on the Colorado, Verde and Williams Rivers in Arizona and Utah has been asked of Federal Power Commission by Fred T. Coulter, Arizona Water Trustee, of Phoenix, Ariz. Output is to be sold in Arizona, California, Colorado, New Mexico and Utah and water is be supplied to irrigate 4,455,000 acres in Arizona. The two largest projects will be: In Glen Canyon, a dam 1700 ft. long by 693 ft. high with 7,000,000 installed horsepower; and in Bridge Canyon, a dam 975 ft. long by 825 ft. high, with 1,100,000 hp.

THE A. P. GREEN FIRE BRICK Co. announces the appointment of Bradshaw & Company, 530 Fourth Ave., Pittsburgh, Pa., as their representative for the A. P. Green Refractory Specialty products.

THE FRANKLIN INSTITUTE of the State of Pennsylvania just made its first award of the Vermilye Medal "in recognition of outstanding contribution in the field of industrial management" to Lewis H. Brown, President of the Johns-Manville Corp. Presentation of the medal was made in Philadelphia, Tuesday, November 14, 1939.

AWARDS of honorary life membership in The Institution of Mechanical Engineers were presented to two members of the American Society of Mechanical Engineers: Alexander G. Chris-



NOT MARTIANS FROM MARS——
BUT PIPE HEADERS FROM KELLOGG

These strange looking pipe headers were not inspired by H. G. Wells' "War of the Worlds." They were designed and prefabricated to perform a particular function for a Kellogg customer.

Prefabricated complete in the Kellogg Shops, these headers were shipped ready to connect on the job. They are made of 20" O.D. pipe, ⅜" thick, and are fitted with 17 accurately located nozzles—"Masterwelded" to the main shell.

The high quality of Kellogg shop-welding and the skill of Kellogg craftsmen are convincingly demonstrated in these headers.

If you have an unusual piping problem consult a Kellogg Engineer.

KELLOGG

THE M. W. KELLOGG COMPANY

JERSEY CITY • NEW JERSEY • 225 B'WAY, N. Y.

REPRESENTATIVES

LOS ANGELES 1031 SOUTH BROADWAY HOUSTON, TEXAS
CHICAGO 122 S. MICHIGAN AVE. TULSA PHILTOWER BLDG.

"Masterflex" Prefabricated Piping Systems. "Masterweld" pressure vessels for Power, Refinery and Chemical Industries. Heat Exchangers. Pyrolytic Cracking Units. Thermal and Catalytic Polymerization Units. JUIK Processes for Lubricating Oil Plants. Plastic Refractories. Radial Brick Chimneys.

tie, president of the Society and professor of mechanical engineering at Johns Hopkins University, Baltimore, Md., and, Henry Ford, well known industrialist of Detroit, Mich.

ARMOUR INSTITUTE OF TECHNOLOGY, Chicago, Ill., announces the following new faculty appointments in Mechanical Engineering for the year 1939-40: Dr. L. H. Donnell, associate professor, formerly with the Goodyear Co.; Eugene Murphy, part-time instructor, formerly with Ingersoll-Rand; H. B. Nottage, instructor, formerly at University of California; and, Paul R. Trumpler, instructor, formerly at Yale. Professor P. C. Huntly, formerly head of the Mechanical Engineering department, has been appointed head of the Civil Engineering department, while Professor James C. Peebles has been appointed Acting Head of the Mechanical Engineering department for the year 1939-40.

Armour and Lewis to Form Illinois Institute of Technology

ILLINOIS INSTITUTE OF TECHNOLOGY is the name given the new school that was formed by consolidation of the Armour Institute of Technology and Lewis Institute. This announcement came from James D. Cunningham and Alex D. Bailey, Chairmen of the Boards of the respective institutions.

Lewis Institute was founded as the result of the will of Allen C. Lewis who, at his death in 1877, left his entire estate for the establishment of a first class polytechnic institute. Armour Institute of Technology was founded by Philip D. Armour in 1892. Mr. Lewis and Mr. Armour were both motivated by the same desire, namely to provide educational facilities for young men and young women who were unable to advance themselves in life without such assistance. The merging of these two institutions brings together the resources provided by Mr. Armour and Mr. Lewis, and enables their basic objectives to be achieved in a manner which conforms with existing conditions.

The new college becomes one of the largest technological centers in the world, the objective of which is to integrate the fields of science, engineering, management, and humanities, now taught in both colleges, in a manner which will broaden and strengthen the whole.

Greater opportunities for adult education enabling employed young men and women to secure a college education while earning a living is made possible by the evening curricula in the adult education division which will offer the degree of Bachelor of Science in all of the major fields of engineering, arts, and science.

The actual consolidation of the educational program will be complete by September, 1940, and the balance of this year will be given over to planning an integration of activities. For the time being, it will be necessary to operate both the Armour and Lewis plants, but the complete development of the new center of technology contemplates the acquisition of a new, well-planned campus, conveniently located, to meet the needs of its broad objectives.

Illinois Institute of Technology will be controlled by a Board of Trustees of fifty-five members, made up of the present trustees of both Armour and Lewis.

Iowa Hydroelectric Power Project to cost $3,500,000

THE FIRST Iowa Hydro Electric Cooperative, Moscow (Muscatine County), Iowa, Harry Strong, manager, has been organized recently to construct and operate a hyroelectric power development on the Cedar River, vicinity of Moscow, and preliminary plans for the project are now in progress. Application has been made to the State for permission to construct the necessary dam and proceed with the development. The power dam will be about 35 ft. high and 9750 ft. long, earth-fill type, with concrete crest to serve as a two-lane motor highway. The generating station will have an initial rated capacity of about 15,000-kw. Project will include transmission lines for connection with rural electric cooperative systems in that vicinity, which propose to secure power supply from this source. Entire development is estimated to cost $3,500,000, and a bond issue in this amount will be arranged as soon as necessary authority for projcet has been secured.

A. Eugene Michel

A. EUGENE MICHEL, owner of the technical advertising firm of A. Eugene Michel and Staff, New York City, died November 9 at his home in New York. He was 59 yr. old and for almost 40 yr. was prominent in engineering circles as designing engineer for the Diamond Chain Mfg. Co.; foreman of the Ewart Mfg. Co.; assistant manager of publicity of the International Steam Pump Co. and later of Johns-Manville Corp.; manager of the Gorge H. Gibson Co. and, finally as head of his own agency. He was widely known as a philatelist, specializing in Government stationery, and his collection will be maintained in its entirety at the Smithsonian Institution in Washington.

R. S. MacPherran Retires

RALPH S. MACPHERRAN, Chief Chemist of Allis-Chalmers Mfg. Co. for many years and identified with the iron and steel industry for nearly 50 yr., is retiring from active service with the Company. According to an announcement by Vice President William Watson, Harold J. Stein, Research Engineer of the Manufacturing Department has been appointed Director of Research, Chemistry and Metallurgy of the Allis - Chalmers Mfg. Department, now bringing all these activities under one head. His assistant will be J. T. Jarman.

Ralph S. MacPherran

Harold J. Stein

Mr. MacPherran is especially noted as an outstanding metallurgist in the field of gray iron and has long been active in many technical societies connected with his profession. In 1931 he was selected to receive the coveted J. H. Whiting gold medal award of the American Foundrymen's Association. He graduated in Chemisty at the University of Michigan and has been with Allis-Chalmers since 1895, having started with the old E. P. Allis Co. Mr. Stein started with Allis-Chalmers as a graduate student apprentice in 1916 and during his period of training served in the various manufacturing departments including detail, erection and test and in 1936 was made Chief Research Engineer of all the Manufacturing Departments.

American Locomotive Co.

EFFECTIVE October 18, 1939, C. S. Patton was appointed Sales Manager of the Alco Products Division of the American Locomotive Co. in charge of the sale of heat exchangers, condensers, feed water heaters, evaporators, tubular equipment, code pressure vessels, fabri-

C. S. Patton

cated plate work, water pipe and allied lines. Mr. Patton graduated from Cornell with the degree of Mechanical Engineer in 1918 and previous to his present appointment was Manager of Equipment Sales, Alco Products Div. of the American Locomotive Co.

New Unit for Florida

THE FLORIDA POWER & LIGHT Co. has placed an order with the Westinghouse Co. for a 25,000-kw turbine generator to be installed in its Lauderdale Steam-Electric Station at Dania, Florida. This is to be a single-cylinder condensing turbine driving a 3600 rpm, 13,800 volt hydrogen-cooled generator. The generator will be one of the first to make use of the spring-mounted stator to reduce 180 cycle vibration. In many respects the machine is similar to the air-cooled Westinghouse generating unit recently placed in service in the Ripley Steam-Electric Station of Kansas Gas & Electric Co. It is expected that the Florida machine will be ready for operation early in the fall of 1940.

Grand Coulee Economics

WHILE there is no question of its importance as an important engineering achievement, as shown on page 694 of November issue, some data given by Henry Earle Riggs in Public Utilities Fortnightly, April and May, 1938, may be of interest to readers to give them basis for judging as to economic advisability of the project.

For the territory to be served with electric power, Washington and parts of

VERSATOL
REG. U.S. PAT. OFF.
INSULATED CABLE

75 C

How It Saves on Copper

ALL THREE properties most desired in a rubber insulation for cable are combined in Versatol—moisture resistance (0.010), long life (504), and heat resistance (75 C). The last-named property makes possible savings in copper.

Take, for example, these two conductor sizes:

550,000 cir mils
350,000 cir mils

The difference between them indicates an actual saving in copper that Versatol insulation makes possible. The reason lies in its operating temperature of 75 C.

As you probably know, standard 30-per-cent rubber has for years performed satisfactorily at 60 C. The newer 30-per-cent compounds, such as G-E R-328, have even better aging properties. Versatol, however, can be operated up to 75 C. This means a higher allowable temperature rise under the same conditions of installation; or, in other words, a smaller conductor size for a given number of amperes.

In arriving at the above figures, we assumed a current of 315 amperes at 2300 volts, carried for 1000 feet. The cable was a three-conductor Type RJIJ,* supported aerially by messenger, and a 40 C ambient temperature. For 30-per-cent rubber, the conductor size needed was 550,000 cir mils; for Versatol, it was 350,000 cir mils.

*R, Rubber-insulated; J, jute bedding; I, interlocked steel armor; and J, jute over-all protection.

What 504 and 0.010 Mean

In addition to heat resistance, you get in Versatol the long-life property of 504 hours' aging in the oxygen bomb—or 20 hours' aging in the air bomb—with a maximum allowable depreciation in tensile strength of not more than 25 per cent. These, the most severe aging tests, can be said to indicate a life expectancy of fifty years.

Versatol also has the unusually low moisture-absorption factor of 0.010 gram per square inch of the surface submerged. This may mean savings by the omission of lead sheath. Braided cables insulated with Versatol are approved by the Underwriters' Laboratories, Inc., for use in moist locations where heretofore lead-sheath cables were required by Section 3035 of the 1937 National Electrical Code.

Savings on submarine cable by the omission of lead sheath could be as much as 40 per cent.

Economic Studies Profitable

For the reason that such savings are possible, there is one point that deserves emphasis: in the selection of cable, it usually pays to take economics into account. Balance first cost against other factors for long-time economy.

In any study made to select the type of cable best fitted for each job, a G-E cable specialist may be able to help. He has helped others; perhaps he can assist you. Ask for his services through the nearest G-E sales office, or address General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

520-170

INSULATED CABLE—ALWAYS THE RIGHT TYPE FOR EACH JOB

Oregon and Idaho, the situation is as shown below:

	Total Installed hp.	Yearly kw. hr. firm power available	Cost of power development estimated
Grand Coulee	2,500,000	7,000,000,000	$204,500,000
Bonneville	690,000	2,000,000,000	30,000,000
Other plants	1,515,000	6,045,000,000	.....

Bonneville cost was estimated at 30 million dollars, but actual cost will be some 52 million.

Population of area to be served is estimated at completion of Grand Coulee as 3,500,000, and total installed capacity 4,905,000 hp. For New Jersey, with population 4,148,000, installed capacity is 1,426,000 hp.

Irrigation is emphasized as the prime reason for Grand Coulee, but all engineers report that it can be justified only if power sales can provide sufficient income to carry and liquidate both power and irrigation installations. Irrigation works are estimated to cost $210,000,000 for reclaiming 1,200,000 acres, or $175 an acre. For all other reclamation projects, the cost has been $254,522,745 to reclaim 3,709,150 acres, or $68.60 an acre.

New Station for Philadelphia

LATE in October, Horace P. Liversedge, president of The Philadelphia Electric Co., announced the purchase of a site at Delaware River and Oregon Ave. as the first step toward a new $45,000,000 plant to be known as Southwark Station. The first step in the development will be a distribution center to be later connected with the new station. Preliminary work on the station will probably be started in 1941 on the basis of an ultimate capacity of 500,000 kw. This projected program on top of last year's $6,000,000 expansion at Schuylkill Station and this year's $7,000,000 expansion program at Chester Station is, said Mr. Liversedge, "action which continues to guarantee an adequate power supply in the Philadelphia area . . . to bring new industries to Pennsylvania. One of the basic requirements for holding present industries and bringing new . . . is low cost, reliable electric power." The new plant site has been owned since 1867 by the Pennsylvania Salt Mfg. Co. which will move its chemical operations to another site in the Philadelphia area.

General Electric Elects New Officers

CHARLES E. WILSON, executive vice president, was elected president and Philip D. Reed, assistant to the president, was elected chairman of the board of directors of the General Electric Company at the meeting of the directors of the Company in New York City, November 17. They will take over their new responsibilities January 1, succeeding Gerard Swope and Owen D. Young, who will become honorary president and honorary chairman of the board, respectively.

At the board meeting a letter, jointly signed by Mr. Young and Mr. Swope and dated at New York, November 17, explained their reasons for asking for retirement at this time. The letter reads: "To the Board of Directors:

"On May 16, 1922, we undertook at your election the offices of chairman and president, respectively, of the General Electric Company, and as a result of your designations we have held those offices ever since. When we took office we indicated our view that it would contribute to the morale and effectiveness of the organization if as a general rule men in important administrative positions would consider retirement when they reached the age of 65. We realize that there have been, are, and probably always will be exceptions where it is desirable in the Company's interest for men to continue in their place beyond that age. Having adopted that policy of retirement during our administration, we now apply it to ourselves. We do so with no reservation because there are younger men, whose experience and capacity have been demonstrated to you, who are now available for those offices. Accordingly, we now ask for retirement from the offices of chairman and president, respectively, at the expiration of the present calendar year. We took up these offices together and we wish to lay them down together. We will remain as directors and make ourselves available for such service as you and our successors may deem helpful to the Company. May we express to you and through you to the organization our appreciation of the privilege of working so happily with you and them for these many years."

Owen D. Young (left) chairman of the board of directors of the General Electric Company, greets Philip D. Reed, and Gerard Swope, president of G-E, greets Charles E. Wilson (right) following the announcement at the board meeting on November 17 that on January 1 Mr. Reed will succeed Mr. Young, and Mr. Wilson will succeed Mr. Swope. Mr. Young will become honorary chairman and Mr. Swope honorary president of the company

CHARLES E. WILSON

Charles E. Wilson, who began his career in business as an office boy at the age of 13, has been executive vice president of the General Electric Company since December, 1937. It was a new position when he was appointed to it, after having been vice president in charge of Gerenal Electric's appliance and merchandise department since 1930.

Mr. Wilson was born in New York City on November 18, 1886. He began working as an office boy in 1899 with Sprague Electric, a former constituent company of General Electric. Since then he has served in practically every function of the business and in many capacities.

In 1923 he went to Bridgeport as managing engineer in charge of the conduit and wire business, and two years later he was appointed assistant manager of General Electric's Bridgeport works. Here began his intimate association with the appliance business, and in June, 1928, he became assistant to the vice president in charge of the merchandise department.

PHILIP D. REED

Philip D. Reed, the new chairman of the board has been assistant to the president of the General Electric Company since December, 1937. He was born in Milwaukee, Wis., on November 16, 1899.

He joined the General Electric Company in its law department in 1926, one day before his 27th birthday. He holds degrees both in electrical engineering and law. He received his engineering degree from the University of Wisconsin in 1921 and his doctor of laws from Fordham University in 1924. He is a member of Tau Beta Pi, honorary engineering society.

Mr. Reed's first job began while he was still a law school student, taking evening classes at Fordham, and in 1922, before his graduation, he became vice president and patent counsel for the Van Heusen Products Company of New York. Before that he was patent solicitor for Pennie, Davis, Marvin & Edmonds of New York, and patent attorney for J. M. Van Heusen of Boston.

He entered the General Electric Company in 1926 as assistant to vice president C. W. Appleton of the Company's law department in New York. In 1928 he was transferred to the incandescent lamp department, and from July 1, 1934, until his appointment as assistant to the president in December, 1937, he was general counsel for the lamp department.

PIPING BY
MIDWEST

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For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Controls, Meters and Instruments

Pressure Reducing Regulators—An illustrated 8-pp. Bulletin 2 with complete information on six types of spring and weight-loaded valves used for the automatic regulation of steam, air, liquid or gas pressures. The Foster Engineering Co.

Industrial Thermometers. A new industrial thermometer Catalog No. 1125C is a book containing 24 pp. of conveniently arranged listings of the complete line of TAG Industrial Thermometers; hygrometers (wet and dry bulb thermometers), U-gages, mercurial vacuum gages, and mercurial barometers. C. J. Tagliabue Mfg. Co.

Flame Detector—This 8-pp. bulletin, No. 210, points out that the best assurance against explosion hazards from loss of ignition is for operators to be fully acquainted with ignition furnace conditions. The bulletin describes and illustrates the construction and application of this device to afford protection against furnace explosions. Bailey Meter Co.

Heat Transfer—What to think about when you buy constant temperature laboratory equipment is the title of Bulletin 305 containing a practical discussion of the subject of heat transfer, with a brief review of heat transfer principles and an outline of technical considerations affecting the rate of heat transfer, variations in quantities required, attributes of peak performance and aspects of efficiency. Precision Scientific Co.

Mechanical Power Transmission

Hydraulic Couplings—Scoop Control Fluid Couplings For Industrial Variable Speed Control is the title of a new 8-pp. catalog in color, Bulletin 3719. Fluid drive is applicable to engineering problems involving difficult starting, shockless drive and acceleration, connection and disconnection of loads, protection against overloads, variable speed and the absorption of torsional vibration. The new arrangement simplifies the control to a single movement of a simple lever which may be under direct, remote or full automatic control. American Blower Corp.

Transmission Equipment—Catalog No. 1339 contains revised, up to the minute information on all S-A car pullers, hoists and sheaves plus information on certain hand and motor operated winches. Included are the new No. 14 wire rope car puller and a new section on rope for car pullers Stephens-Adamson Mfg. Co.

Bearings—Engineering data on the Orange Staggered Roller Bearing is completely covered in a new booklet giving sizes, capacities and typical applications. Orange Roller Bearing Co. Inc.

Pivoted-Motor Leather Belt Drives—Automatic tension control, short center pivoted-motor leather belt drives is an 8½ by 11 in., paper bound, spiral bound, 134 page book produced cooperatively by 46 manufacturers of leather belting and motor bases The book consists of a 40-page technical section, catalog sections by several manufacturers and price lists on drives and pulleys of all kinds. The technical section covers the advantages of this type of drive, gives the results of tests of Worcester Polytechnic Institute, comparative efficiency curves, power and capacity rating tables and a price comparison of the drives. Because of the limited edition, requests for copies by those interested should be made immediately. American Leather Belting Association.

Electrical Equipment

Capacitor-Motor Servicing—Catalog No. 168A is devoted to the new Test-Mike and Service-Mike for a.c. motor starting capacitor service tests. It covers the locked-rotor torque test, methods of making tests, selection of capacity value, making permanent repairs, check on overloads, with additional service notes Included on these pages are connection diagrams and a diagram of switch positions. Cornell-Dubilier Electric Corp.

Electrical Equipment — Nineteen new bulletins have been issued discussing various types of electrical equipment. The numbers and subjects of the bulletins are: GEA-1807B, Squirrel-Cage Induction Motors; GEA-821G, Pressure and Vacuum Switches, CR2927; GEA-98B, Type RB Motor; GEA-2230A, Rotating-Cam Switches, CR3300; GEA-3187A, Type CF-1, Portable Inkless Strip-Chart Recorder; GEA-3215A, No. 1799 Heat-Resisting Varnished Cambric Cable; GEA-1698A, Wound-Rotor Induction Motors, Types M and MT; GEA-3281, Types AEF-1B and ALF-2 Field Discharge Switches; GEA-2634, How to Select Protective Devices for Low-Voltage Power Circuits; GEA-3043, Limit Switches CR9440-CR9441, Lever, Push-rod and Rotating Types; GEA-3228 Gas Absorbers and Vent Pipes for Pyranol Transformers; GEA-3282, It has the Big Features of Big Breakers —The New FK-142 Oil Circuit Breaker; GEA-2150B, Diactor Generator-Voltage Regulators Type GDD; GEA-1945A, Synchronous Motor-Generator Sets; GEA-3226, Demand Meters; GEA-1191B, Synchronous Motors; GEA-3279, Diactor Generator-Voltage Regulators; GEA-3268, He Isn't Loafing—The Power Is Off; GEA-2423A, Thinwol Control Cable. General Electric Co.

Generator Air Coolers with finned cooling elements are described in a new bulletin No. 1219. Application of these units, K-Fin Air Coolers, is illustrated by photographs and construction drawings. The Griscom-Russell Co.

Stokers and Furnaces

Refractories—Bulletin R18, 4 pp., describes the characteristics of K-16, a light weight insulating firebrick of high stability and hot load strength and Bulletin R19, 4 pp., a light weight castable refractory insulating concrete-mix with a density of from 47 to 60 lb. per sq. in., made in two grades K-20 and K-22 for service temperature limits of 2000 and 2200 deg F. respectively. The Babcock & Wilcox Co.

Furnace Walls—A new 4-pp. bulletin shows by maintenance costs, a comparison between solid walls and Reintjes Supported wall. Geo P. Reintjes Co.

Water Cooled Furnaces—Bulletin G16 is a 32 pp. catalog in color setting forth the purpose, requirements and construction for modern water cooled furnaces on boilers of all sizes. It is illustrated with photographs and drawings of typical units for different fuels and for both wet and dry bottoms. The Babcock & Wilcox Co.

Stoker—A new concise bulletin shows recent installations and gives construction features of this new air-cooled spreader type overfeed stoker designed for use with all types of furnaces and boilers from 80 to 2000 hp. The Continental Roll & Steel Foundry.

Compressors and Refrigeration

Diesel-Driven Compressors—A new line of stationary Diesel-driven, two-stage air compressors, known as the Class W-CO, and built in a capacity range of 662 to 2000 c.f.m. are described in a new bulletin, No. 767. Chicago Pneumatic Tool Co.

Refrigeration—Carbondale low pressure refrigeration units from ¼ to 25 hp. are illustrated and described in Bulletin C-1100-B6 giving complete specifications. Bulletin C-1100-B7 discusses Carbondale refrigeration units which range in size from 75 to 125 hp. Worthington Pump & Mach. Corp.

Fans and Air Conditioning—Bulletin A32029 is a 48 pp. summary of the company's products including fans, blowers, dampers, air conditioning equipment, unit heaters, hydraulic couplings and dust collectors. Each piece of equipment has a short description and reference to special bulletins and catalogs which cover the separate items of equipment in greater detail. American Blower Corp.

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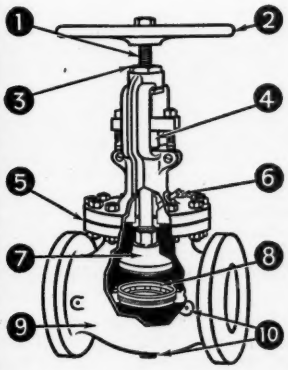

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Water Treatment

The Art of Proportioning—This 24 pp. catalog, the second printing of the booklet entitled The Art of Proportioning, describes the application of the Haering Fluid Piston Principle to liquid proportioning problems. The use of pitot tubes and hydraulic principles involved in proportioning are described and explained. Proportioning units for handling all types of reagents are included in this catalog. D. W. Haering & Co., Inc.

Scale and Corrosion Control—The third edition of the 16-pp. booklet, Organic Methods of Scale and Corrosion Control, incorporates additional information regarding the application of organic chemicals to various industrial problems as well as descriptions and properties of a number of compounds not covered in earlier editions. D. W. Haering & Co., Inc.

Pumps and Engines

Pumps—Two new bulletins on Monobloc Centrifugal Pumps illustrate and describe this product. The bulletins are designated by the following numbers: W-321-B14 and W-322-B1D. Worthington Pump & Mach. Corp.

Centrifugal Pump—A new bulletin B-6018, How to Get More Gallons at Less Cost is an enlarged and revised edition on SSUnit close-coupled pumps. It gives well illustrated presentation of small size pumps, including construction details, performance data, capacity tables, dimension sheets, and friction tables. Allis-Chalmers Mfg. Co.

Gas Engine—Type EEG Vertical Four Cycle totally enclosed gas engines are illustrated and described in Bulletin S-550-B15. Bulletin S-550-B17 gives a complete treatise on Unibloc Gas Engine Compressors. Worthington Pump & Mach. Corp.

Traps, Valves and Piping

Hose—The Fact Book of Flexible Metal Hose and Tubing tells the story of an engineering achievement which for many years has utilized the inherent qualities of metal construction in the solution of one of industry's most difficult problems. Flexible Metal Hose and Tubing Institute.

Model-B, a Beaver Portable Power Pipe Threading Machine, is illustrated and described in a new bulletin. Beaver Pipe Tools, Inc.

Ratchet Pipe Threader — A new leaflet illustrates and describes the Toledo No. 1R Ratchet Pipe Threader, a new product of the Toledo Pipe Threading Machine Co.

Valves—Catalog 78 illustrates, describes and lists a complete line of bronze, iron and steel valves; boiler mountings; lubricating devices; oil and grease cups, whistles, cocks, fittings. The Lunkenheimer Co.

Valves—A reprint of 6 pp. of photo news on valve values has just been issued by The Edward Valve & Mfg. Co., Inc.

The ADSCO Packless Expansion Joint—U-Ring Type is illustrated and described with list prices and dimensional data in a new Bulletin No. 35-50A. American District Steam Co.

K-Master Steam traps of the inverted bucket type are illustrated and described in a new 20-pp. bulletin covering the design, operation and application. Capacity tables and list prices are also included. Kaye & MacDonald Inc.

Traps—The Armstrong Steam Trap Book, Catalog H, 36 pp. in colors, is a combination handbook on condensate drainage and a catalog; covers traps and accessories, with data on sizing, manufacture and installation, recommended practice, useful engineering tables and prices. The Armstrong Machine Works.

Miscellaneous

Weld-O-Tron—a new low current electronic welder for precision work is illustrated and described in a new bulletin B-6049. Allis-Chalmers Mfg. Co.

Acidseal Paints—A 4-page catalog section lists all properties of Acidseal Paints, directions for use, each type, with its special properties, and includes an exact reproduction of the different colors in which the paints are made. The B. F. Goodrich Co., Akron, Ohio.

Acoustical Telephone Booths—How an acoustically lined telephone booth even though doorless, controls and dampens interfering extraneous noise is explained in a new booklet entitled Burgess Acoustical Telephone Booths. Burgess Battery Co.

Keldur—A new synthetic material for insulation of vibration of shock and noise is illustrated and described in a new bulletin giving uses, specifications and methods of installation. Keldur Corp.

Ladders—A new 24-pp. catalog, Aluminum Ladders for Every Requirement, illustrates and describes 18 standard types of aluminum ladders and stages. Included are two and three section extension ladders; single wall ladders; warehouse ladders; scaffold ladders; and solid, open and folding type step laders. Aluminum Ladder Co.

South Bend Lathes—Floor leg lathes, bench lathes, metric lathes are illustrated and described in a new 112-pp. Catalog 100. Attachments, features and specifications are also included. South Bend Lathe Works.

Blower—A 20-page bulletin No. 120-B11, illustrates and describes the blowers and exhausters. Pressure-volume curves and information regarding operating characteristics of this equipment are given. Blowers in various arrangements for motor and steam turbine drive are illustrated. Roots-Connersville Blower Corp.

Slabs. The Engineering Experiment Station of the University of Illinois, Urbana, Ill., has recently published two bulletins, No. 84 Tests of Plaster-Model Slabs Subjected to Concentrated Loads and No. 85, Tests of Reinforced Concrete Slabs Subjected to Concentrated Loads. These bulletins normally sell for 60 and 80 cents per copy, respectfully, but a limited number of copies are available for free distribution.

Proceedings of the 35th Annual Meeting of the American Wood-Preservers' Association, 1427 I Street, N.W., Washington, D. C., has been published by the Association as a 5½ by 8½ in., 412 pp., cloth bound book selling for $6.00. Aside from the material of interest only to that industry, the proceedings are of value to the utility and industrial engineer because of the information on treatment of poles, ties, posts and timber for preservation and fireproofing, and the relation of corrosion of metal fastenings used in treated wood. Of particular interest to utilities is a 10 pp. report on pole service records, covering thousands of poles, some set over a period extending back as far as 20 yr.

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Link-Grate Continuous Ash discharge Stoker in Columbus, O. plant of the Timken Roller Bearing Co. Boiler capacity 60,000 lb. of steam per hour.

CHEAPER COAL . . . *plus* INCREASED EFFICIENCY

The Timken Roller Bearing Co. is burning cheaper coal at its Columbus, Ohio plant and making these savings:

$3480 annual saving by use of lower cost fuel. This saving alone will return the cost of the stoker in 4 years' operation.

Even greater savings are being realized in increased steam generating efficiency — 74% to 84%.

Maintenance cost for 12 months — ZERO.

These data are taken from the owner's records.

Real Savings in the Boiler Room

Westinghouse Link-Grate Stokers are making definitely measurable savings — forming an important part in the annual operating statement — in the many plants in which they are installed. It will pay you to visit one of these plants.

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There will be no obligation in asking us to send an experienced stoker engineer to make a study of your plant. Chances are he can show you ways to save money — to get better results from your boiler room. Just ask any Westinghouse office.

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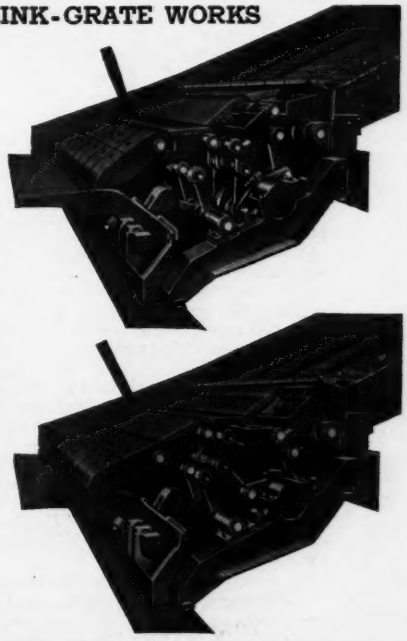

Arrows indicate the extreme positions of the grates during the wave-like motion which constantly agitates fuel bed and assures thorough combustion. This motion of the Link-Grate also conveys refuse to, and discharges it from the rear end of the stoker.

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Westinghouse Stokers

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New Engineering Books

You and Your Money. By C. Donald Dallas. Third edition; cloth bound; 85 pages; 5½ by 8½ in.; illustrated; price $1.50; published by Prentice-Hall, Inc., New York city, 1939.

With so much being published these days criticising the American capitalistic system, it is refreshing to read this revised and enlarged edition of "You and Your Money," for it gives you a feeling that all is not lost and even with its many faults the American system gives opportunities for every normal man to develop economic independence through the exercise of industry, diligence, frugality and a reasonable knowledge of investment principles. Mr. Dallas, an American business executive, bases his statements and conclusions on statistics gathered from the most reliable sources which he has summarized and presented in tabular and curve forms, thus giving the reader an opportunity to draw his own conclusions independently of the author if he so desires. Following an introductory chapter the book is presented under the following headings: The Present Situation; Capitalization and Communism; Capital and Labor; Labor Relations in England and Sweden; Investments; Investing; Real Estate; Taxes; The Struggle for Security.

Steam, Air and Gas Power. Third Edition. By William H. Severns and Howard E. Degler. Published by John Wiley & Sons, Inc., New York, N. Y. Size 6 by 9 in., 478 pp., cloth bound. Price, $4.00.

Through two editions this book has become too well known to require detailed review. Contents are well indicated by the title and cover fundamental principles of thermodynamics and the application of these principles to the generation of steam and power in all forms. Recent advances in heat power engineering and in steam generating equipment have made numerous changes necessary in this new edition. The chapter on Principles of Thermodynamics has been rewritten and enlarged, steam tables have been added and sections on fuels, feedwater treatment, fans, steam engines, and boilers have been changed materially. The first author is Professor of Mechanical Engineering at the University of Illinois and the second, Professor of Mechanical Engineering and Chairman of the Department at the University of Texas.

Manning Formula Tables. By Horace Williams King. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Size 6 by 9 in., 379 pp., flexible fabricoid binding. Price $5.00.

With the exception of a short introduction of 14 pp., this book is devoted entirely to the main tables and six auxiliary or supplementary tables needed to provide a simple and direct solution from problems involving calculation of flow in open channels by means of the Manning formula. The introduction explains the tables and formula and illustrates their application by the solutions for 19 representative problems.

Heat Power. Second Edition. By Earle B. Norris and Eric Therkelsen. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Size 6 by 9 in., 399 pp., cloth bound. Price $4.00.

The first edition of this book appeared in 1930 as a modern treatment of the principles of heat power engineering. At that time the authors reversed the usual treatment and placed the treatment of internal combustion engines first on the theory that the modern student is already familiar with the automobile engine and that this semi-familiar ground is the proper approach to thermodynamics. The success of the plan was such that the arrangement has been retained in the second edition. Illustrations have been changed throughout the book so as to keep abreast of current practice but the most important additions of the new edition is a chapter on refrigeration, the latest steam tables, answers to the many problems throughout the book and a combustion calculation chart. The first author is Dean of Engineering at Virginia Polytechnic Institute and the second author is Professor of Mechanical Engineering at Montana State College.

Midwest Power Conference Proceedings, Volume II, 1939. Containing 155 pages, this book gives the complete text together with the necessary illustrations of the 19 papers which were presented at the Midwest Power Conference, which was held in Chicago April 5-7, 1939, under the sponsorship of the Armour Institute of Technology with the cooperation of the University of Wisconsin, Iowa State College, State University of Iowa, Michigan State College, Purdue University, University of Illinois, University of Michigan and of local and national engineering societies. The book contains a registration list of those who attended the Conference and a complete copy of the program. The price of the Proceedings is $2.00 and may be secured from Stanton E. Winston, Conference Secretary, Armour Institute of Technology, Chicago, Ill.

Code on Refrigerant Expansion Valves and Proposed Code on Self-Contained Air Conditioning Units—A.S.R.E. Circular No. 16, Proposed Standard Methods of Rating and Testing Self-Contained Air Conditioning Units for Comfort Cooling is the preliminary version of a code which will later be revised and adopted in final form. It covers, in a comprehensive and detailed fashion, methods of rating and testing self-contained air conditioning units for comfort cooling. It classifies various types of these units, describes the method of rating, instruments, apparatus, cooling capacity tests, heating capacity tests, humidifying capacity tests, and gives definitions which will be useful in establishing a standard terminology in this branch of air conditioning.

Standard Methods of Rating and Testing Refrigerant Expansion Valves, A.S.R.E. Circular No. 17, is a 6-page circular giving the final standard which was approved by the A.S.R.E. Council on March 6, 1939. Approved methods of rating thermostatic expansion valves, testing thermostatic expansion valves, rating automatic expansion valves, and testing automatic expansion valves are given, establishing a standard method of procedure which will be a distinct aid to the entire industry.

Copies of these codes are available at 20 cents each from The American Society of Refrigerating Engineers, 37 West 39th St., New York, N. Y.

Results of Municipal Lighting Plants. Author and Publisher, Burns & McDonnell Engineering Co., Kansas City, Mo. Size 6 by 9 in., 350 pages, paper bound. Price $5.00.

This is the sixth edition (1939) of an electric rate book showing the operating records of earnings, output, rates, revenues, valuation, and other information as to the use and cost of electricity in more than 700 municipally owned plants. The volume of 350 pages is accompanied by many interesting graphs and tables showing the increasing use of electricity and the decreasing cost of electricity in municipal installations.

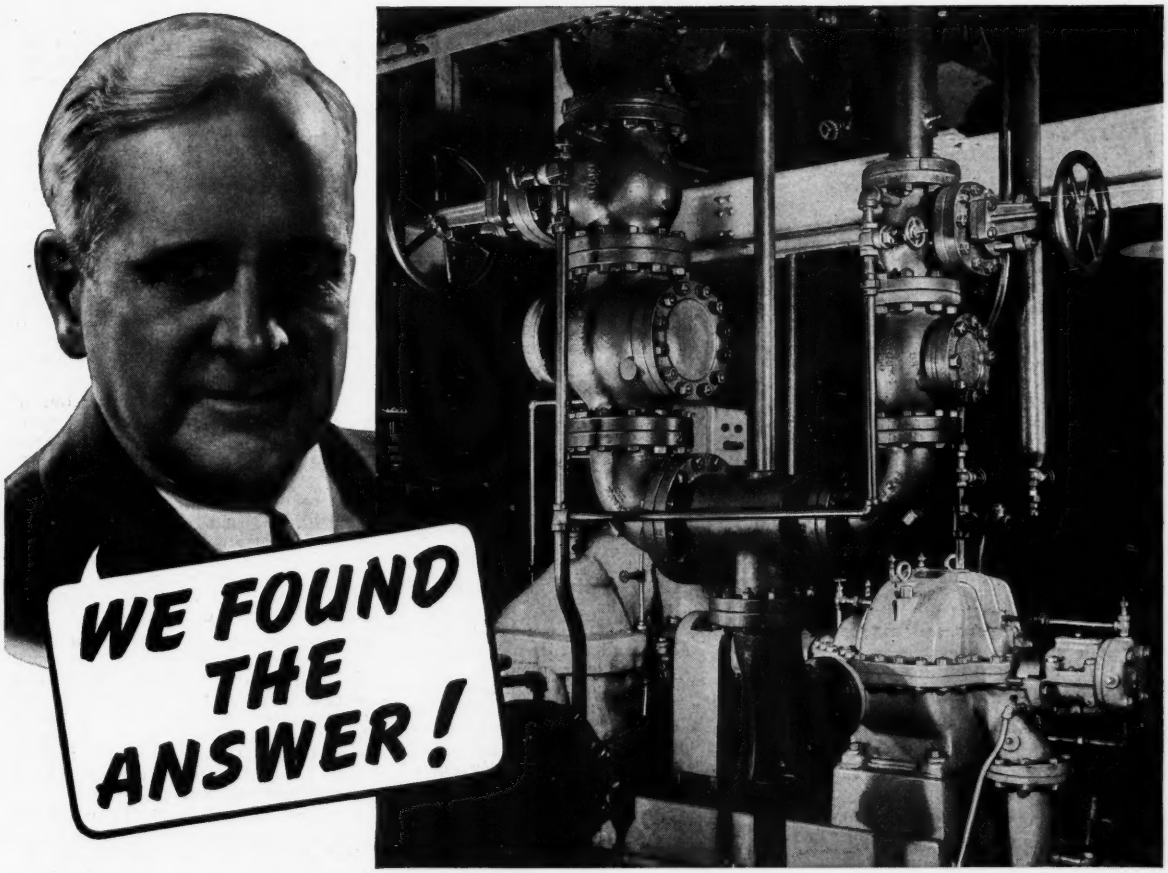
City officials, operators, and managers of both private and municipal plants will find these operating records of much interest and value. Over half the plants in the country have lowered rates since the 1937 edition. A majority of the cities are reported as having no bonded indebtedness on their municipal plants. Every complete and authentic record received from municipal plants has been recorded. As a reference this book should prove valuable to officials who want to keep abreast of the rapidly changing power rates and conditions.

Steam and Hot Water Fitting. By William T. Walters. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in.; 180 pages, cloth bound. Price $2.00.

In writing this book the author had in mind presenting to students and practical men the principles of good heating as influenced by proven design practice, selection of the best possible equipment and proper installation. The book is clearly and simply written, well illustrated and explains the type of equipment used, methods of piping, pipe fitting tools, selection of different kinds of equipment, practical problems in welding, designing the lines for expansion, sizing the mains, risers, branches, returns, etc. There is also a brief explanation of the use of steam tables and how to estimate fuel requirements.

Mechanical Engineering As A Career. Published by The Institute for Research, 537 South Dearborn St., Chicago, Ill. Price $1.00.

This book is a monograph on Mechanical Engineering as a career and should prove very interesting to those who have given consideration to following that profession. It gives the history of engineering and shows the many fields of specialization. Education is completely covered in the book and this will undoubtedly answer the question "What shall I be?" for a number of students who now are in doubt.



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Power Plant Construction News

Calif., Long Beach—Public Utilities Committee of City Council has preliminary plans under consideration for new municipal steam-electric generating station. Cost estimated about $10,600,000, including line construction and power substation units. Proposed to arrange bond issue in amount noted to carry out project.

Calif., San Francisco—Pacific Gas & Electric Co., 445 Sutter Street, is arranging an appropriation of about $25,000,000 for expansion and improvements in power plants and system during 1940, including completion of two of three new steam-electric generating stations now in course of construction in San Francisco Bay area, each with capacity of 67,000-hp.; transmission and distributing lines, power substations and other structures.

Conn., Bridgeport—United Illuminating Co., 128 Temple Street, New Haven, Conn., has plans nearing completion for expansion and improvements in steam-electric generating station on waterfront at Bridgeport, to include installation of a new 25,000-kw. turbo-generator unit, high-pressure boilers and auxiliary equipment. Cost reported over $2,000,000. Westcott & Mapes, New Haven, are consulting engineers.

Del., Edge Moor—E. I. duPont de-Nemours & Co., Inc., duPont Building, Wilmington, Del., plans installation of electric power equipment in new addition to titanium pigment plant at Edge Moor, comprising several new production units. Entire project is reported to cost close to $500,000.

Ga., Brunswick—Brunswick Pulp & Paper Co., plans installation of electric power equipment in connection with expansion and improvements in local sulphate pulp mill for large increased capacity. Cost estimated about $500,-000. E. J. Gayner is general manager.

Ill., Chicago—Heinemann's Bakeries, Inc., 2316 West Foster Street, plans installation of power equipment, ovens, conveyors and other mechanical equipment in new one-story baking plant, 150x200 ft., at Chicago, Wolcott and Bryn Mawr Streets. Entire project will cost over $75,000.

Iowa, Duncome—Common Council plans installation of diesel engine-generator unit and auxiliary equipment for municipal power plant. Appropriation has been arranged through bond issue. Proposed to begin work soon.

La., Baton Rouge—Ethyl Gasoline Corporation, 405 Lexington Avenue, New York, N. Y., plans installation of power equipment in connection with expansion and improvements in branch plant at Baton Rouge, including new production units for large increased capacity. Work will be carried out over period of months. Cost estimated close to $4.000,000.

Md., Baltimore—Consolidated Gas, Electric Light & Power Co., Lexington Building, Baltimore, has approved plans for further expansion in steam-electric generating station at Westport, to include installation of new 67,000-hp. turbine-generator unit, boilers and auxiliary equipment. Work is scheduled for completion in the late spring of 1941. Company now has work under way on addition to same plant to increase capacity by 33,500-hp., to be completed next summer. Entire project will cost approximately $8,000,000, including line construction.

Mich., Grand Rapids—McInerney Spring & Wire Co., plans installation of electric power equipment in new one-story plant for automobile and other steel spring manufacture. It will replace a works recently destroyed by fire. Cost estimated close to $500,000.

Minn., Cloquet—Northwest Paper Co., Inc., plans installation of electric power equipment in new addition to mill, specializing in production of bond and other writing paper stocks. Entire project is estimated to cost about $100,-000. Work is scheduled to begin soon.

Miss., Pascagoula—Jackson County Woolen Mills, Inc., plans installation of electric power equipment in new addition to mill. Cost estimated about $75,000. L. C. Winterton, Pascagoula, is engineer in charge.

Neb., Omaha—Allied Mills, Inc., Twenty-ninth and B Streets, has filed plans for new boiler plant at grain mills, 2900 C Street. Work will be placed under way at once. Cost close to $40,000 with boiler units and auxiliary equipment.

N. J., Paterson—Wright Aeronautical Corporation, Beckwith Avenue, plans installation of electric power equipment in new one-story addition to aircraft engine-manufacturing works, totaling about 300,000 sq. ft. of floor space. Entire project will cost close to $1,000,000.

N. M., Carlsbad—International Agricultural Corporation, 61 Broadway, New York, N. Y., Louis Ware, president, plans installation of electric power equipment in new potash mining and refining plant near Carlsbad where company has a large tract of mineral lands. A power house is proposed. Project will cost about $2,500,000 and will be carried out at early date under direction of Union Potash & Chemical Co., Carlsbad, an affiliated interest.

Ohio, Amherst—Village Council is arranging early call for bids for new municipal electric power plant, for which a fund of $145,000 has been arranged. Board of Public Affairs, Conrad Zilch, president, will be in charge. Floyd G. Browne, Marion, Ohio, is consulting engineer.

Ohio, Cleveland—Cleveland Electric Illuminating Co., 75 Public Square, has plans under way for new steam-electric generating plant at Lake Front Road and East Seventieth Street, to be equipped for an initial rating of 60,000-kw. Cost estimated close to $6,000,000. It is proposed to place orders for equipment soon.

Okla., Oklahoma City—City Council is considering recommendations made by a special water committee for extensions and improvements in municipal waterworks to cost about $4,000,-000. Proposal includes a new municipal pumping plant and filtration station at reservoir to cost close to $1,000,000 with motor-driven pumping units and accessories. M. B. Cunningham is city water superintendent.

Pa., Johnstown—Johnstown Sanitary Dairy Co., Johnstown, plans installation of electric power equipment in new three-story and basement milk products plant in Kernville district. Entire project will cost close to $175,-000. Proposed to begin work early in 1940.

Pa., Titusville—Pennsylvania Refining Co., Spring and Brown Streets, plans installation of power equipment in connection with extensions and improvements in oil refining plant. Also will install a 75-ton capacity refrigeration machine. Entire project is reported to cost over $100,000.

S. C., Chester—Springs Cotton Mills, Inc., Lancaster, S. C., plans installation of electric power equipment in new addition to branch cotton mill at Chester, known as Spring-Stein plant. Entire project will cost over $150,000.

Tenn., Nashville—Aviation Mfg. Corporation, 420 Lexington Avenue, New York, N. Y., plans installation of electric power equipment in new aircraft-manufacturing plant on Murfreesboro Road, near Berry Field airport, Nashville, where company has secured tract of about 25 acres of land. It will comprise several large units. A power house will be built. Cost estimated close to $1,000,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Texas, Coleman—City Council plans extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Cost estimated close to $85,000, of which about $50,000 will be represented by a bond issue, to be voted soon. Terrell Bartlett Engineers, Inc., Smith-Young Tower Building, San Antonio, Tex., is consulting engineer.

Texas, Dallas—Lone Star Gesoline Co., 1915 Wood Street, Dallas, plans installation of power equipment in new distillate recovery and recycling plant in Cayuga oil field area, East Texas, including compressor station, pumping plant, power house and other operating units. Entire project will cost close to $200,000.

Wis., Milwaukee—Wisconsin Cold Storage Co., 344 East Florida Street, plans early erection of new five-story and basement cold storage and refrigerating plant, 105x150 ft., at East Florida and Davidson Streets. Cost reported over $125,000, with equipment. Henschien, Everds and Crombie, 59 East Van Buren Street, Chicago, Ill. are architects and engineers.

Wis., Owen—Western Condensery Co., plans addition to steam power house at plant, to include installation of new boiler unit and auxiliary equipment. Proposed to begin work soon. G. A. Krasin, Marshfield, Wis., is architect.

Wis., Sheboygan—Wisconsin Power & Light Co., Madison, Wis., plans expansion and improvements in steam-electric generating station at Sheboygan, including installation of turbine-generator unit and accessories, high-pressure boilers and auxiliary equipment to increase capacity by 30,000-kw. Cost estimated about $2,000,000. Work will be carried out during 1940.

TURBINES *serve auxiliary drives at Schuylkill*

When the Philadelphia Electric Company modernized the important downtown Schuylkill Station, Elliott Turbines were selected for certain important auxiliary drive jobs.

Boiler-feed pumps are driven by three Elliott 2000-hp. turbines — variable speed, non-condensing, extraction type machines. Steam is bled between the first and second stages to supply heaters and a 50,000 lb. per hr. two-effect evaporator system. The boiler-feed pumps develop 1288 lb. pressure and two of the pumps operating in parallel are capable of pumping 1,470,000 lb. per hr.

Three tank pumps are also driven by Elliott 390-hp., 3500-r.p.m. turbines. These pumps handle 220 deg. F. condensate and two units in parallel will discharge 1,240,000 lb. per hr.

Elliott turbines are thus important factors in the heat balance scheme of this admirable station. Important drives like these justify dependable turbines.

When you want turbine dependability, check with the Elliott engineer.

Built by

ELLIOTT

TURBINE-GENERATORS
ENGINE-GENERATORS
MOTOR-GENERATORS
GENERATORS • ENGINES
MOTORS • MECHANICAL
DRIVE TURBINES • STEAM
JET EJECTORS • FEED WATER
HEATERS • CONDENSERS
CENTRIFUGAL BLOWERS
DEAERATORS • DEAERATING
HEATERS • DESUPERHEATERS
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SEPARATORS • GREASE
EXTRACTORS • FILTERS
NON-RETURN VALVES
LAGONDA & LIBERTY
TUBE CLEANERS

ELLIOTT COMPANY

Steam Turbine Dept.

JEANNETTE, PA.

District Offices in Principal Cities

Published monthly by the Technical Publishing Co., at 53 West Jackson Blvd., Chicago, Ill. U. S. A. Subscription price $2.00 a year. Single copies current issue, 25c. Entered as second class matter September 8, 1932, at the Post Office, Chicago, Ill., under act of March 3, 1879. Vol. XLIII, No. 12.

For Snappy Performance—

IN THE WORDS of an enthusiastic customer: "Armstrong Unit Trapping makes old equipment work like new and new equipment work better than you ever thought it could!"

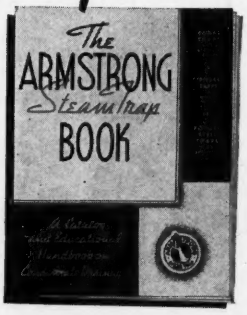
This is a strong statement, but we believe that Armstrong traps backed up by Armstrong Representatives can make good on the promise. These men have had wide experience in the application of Armstrong traps and can give you valuable assistance when it comes to increasing production capacity and straightening out kinks in heating systems.

Armstrong traps are offered in a complete range of sizes and styles for every purpose. In each size, you get the genuine inverted bucket operating principle with the patented Armstrong free-floating valve. For complete information about Armstrong traps and Armstrong service, write or call. ARMSTRONG MACHINE WORKS, 810 Maple St., Three Rivers, Michigan.

VALUABLE INFORMATION *for Engineers*

IF YOU have anything to do with the design or operation of power plants, process plants, or heating systems, we believe you will be very much pleased with the new Armstrong Steam Trap Book. Out of a total of 36 pages, 18 are devoted to data book material on condensate drainage, heat transfer, piping layouts, trapping practice, maintenance ideas, and other useful information never before found in such compact and convenient form. Regular users of Armstrong traps will also be pleased to find new style catalog pages listing Armstrong products with great completeness and detail.

Your local Armstrong representative will be glad to provide you with a copy of this new book, or write. No obligation.



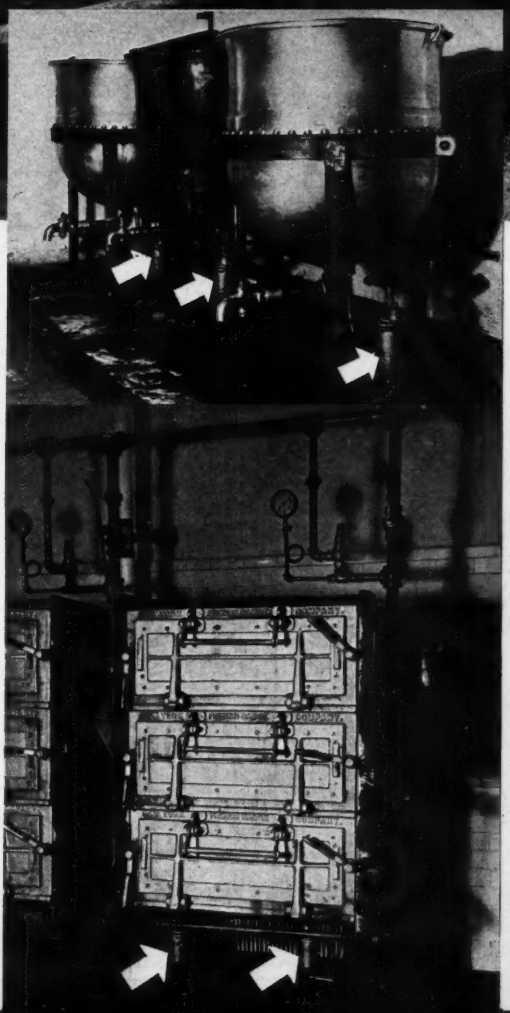
JUST OFF THE PRESS

Change over to ARMSTRONG

NEW YORK MILITARY ACADEMY
CORNWALL-ON-THE-HUDSON, N.Y.

Celebrating An Anniversary

FIFTY YEARS AGO, New York Military Academy was founded at Cornwall-on-the-Hudson, New York. Through this long period of years, the institution has won wide fame for its high standards and its sons have gone on to achieve enviable records in many branches of endeavor. This year has been a gala year with many visitors making it the occasion for viewing the beautiful campus and the well equipped halls, as well as thrilling at the parades, demonstrations, and athletic contests of the cadets. The above picture shows one of the cadet companies in full dress. Some of the modern kitchen equipment is shown at the right.

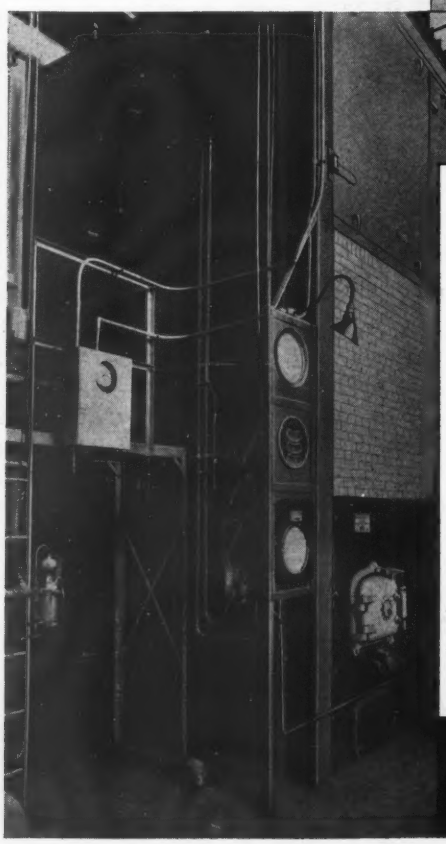


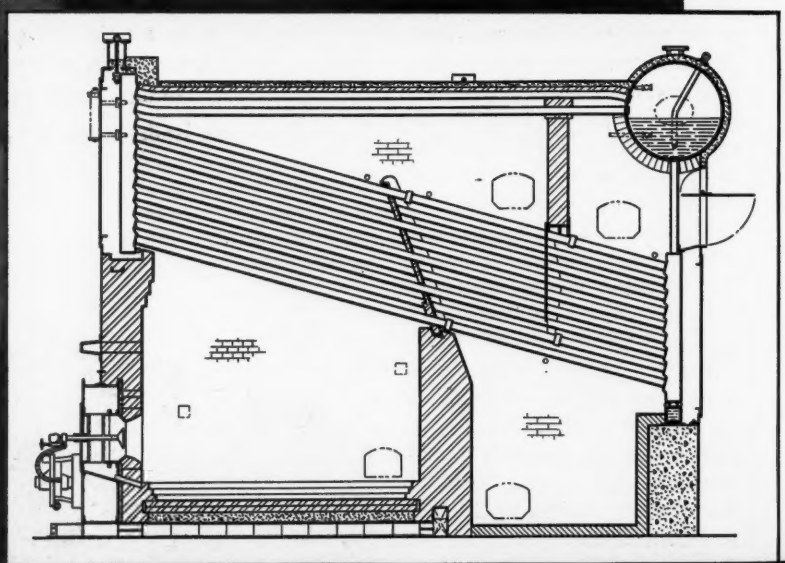
Making Plant Improvements

THIS YEAR has also been an important one for various service departments at New York Military Academy as a result of a change-over to ARMSTRONG UNIT TRAPPING. In the kitchen, the cooks report that hams cooked so fast after the traps were put in that the skins were cooked off before anyone realized it. By actual count, potatoes now cook 44% quicker than previously. In the laundry, machines work faster. In the boiler house, steam consumption has dropped remarkably and cadets jokingly claim that the heating system works so smoothly that they sleep through reveille.

UNIT TRAPPING

B&W Design 32 Cross-Drum Boiler





BABCOCK &

With these Advantages of

Sectional-Header Design

• • • *at reasonable cost*

- Straight tubes—easy to look through—easy to clean and renew from outside the boiler.
- Standardized, interchangeable tubes reduce unnecessary inventory of spares.
- Long tube life—because the sectional-header construction provides rapid, positive circulation, with minimized cross currents and eddies.
- No staybolts to act as focal points for caustic embrittlement.
- Headers and drums located so that soot and ash cannot settle on them, absorb moisture and cause corrosion.
- Exceptional safety: highly sectionalized pressure parts—seamless steel tubes.
- Low furnace-walls, hence reduced initial cost and low upkeep of brickwork.
- These and other advantages of the B&W Design 32 Boiler are available at a relatively low cost because this boiler is of simple design, and is standardized for economical manufacture. Erection costs are minimized by the flexibility of the design which permits its installation with fewest building changes.

A new bulletin—G-28—decribes this boiler more fully . . . sent on request.

G-169-T

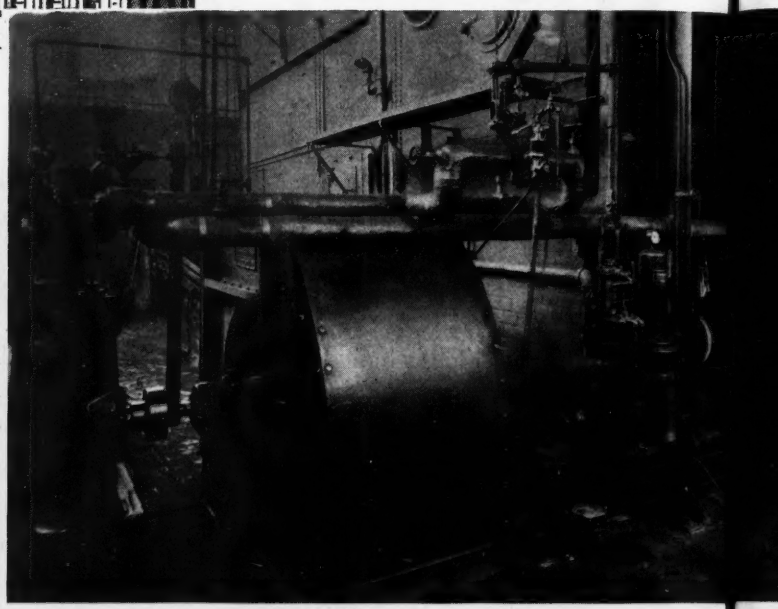
WRITE FOR THIS NEW BULLETIN . . . G-28

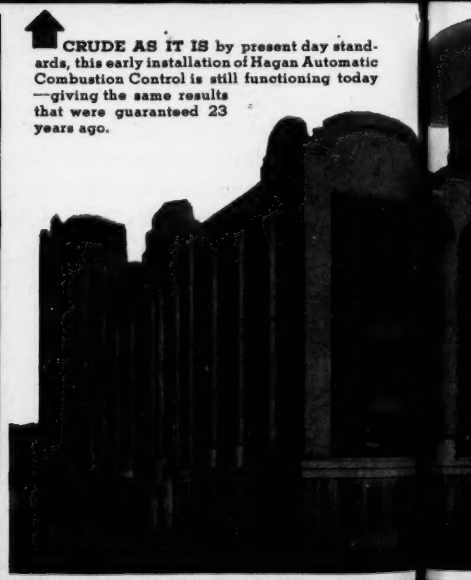
WILCOX

85 LIBERTY STREET
NEW YORK, N. Y.

Born 23

An Idea





CRUDE AS IT IS by present day standards, this early installation of Hagan Automatic Combustion Control is still functioning today—giving the same results that were guaranteed 23 years ago.

COMBUSTION

MODERN INSTALLATION of Hagan Automatic Combustion Control in one of the largest and most efficient stations of a metropolitan power company. This equipment controls combustion for the generation of 700,000 to 800,000 pounds of steam per hour. No job is too big or too difficult for Hagan engineers.

Years Ago!

that changed an Industry

Millions saved in power costs!

WAY back in 1916 two enthusiastic young stoker men, observing their latest installation, humbly confessed to themselves that, no matter how good the stoker, there was still a "missing link" without which a boiler plant would never operate efficiently. They resolved to find it.

Steam pressures fluctuated all over the lot. Maintenance was costly. Fuel waste was high. Excessive smoke, wet steam at high ratings, forced draft equipment, caused endless troubles. Nothing could be more obvious—the "missing link" was lack of adequate control. The problem was how to get it.

It was several trying years before the idea could be turned into reality. Finally they succeeded in developing and producing the first practical system of automatic combustion control. It worked! They knew they had licked the biggest problem in steam production. From it came The Hagan Corporation, the revolutionizing of power plant operation, the saving of millions of dollars.

That was 23 years ago. The original young stoker men are veterans now in a practice that has become universally accepted. From the start, they surrounded themselves with men with whom engineering was a passion. They never lost their instinct for pioneering. There always has been a Hagan Control System ready to meet advancing needs. There always will be. Whatever your problem, we shall be pleased to hear from you.

HAGAN

and CHEMICAL ENGINEERS

THE HAGAN CORPORATION

300 ROSS STREET · PITTSBURGH, PA.

MODERN C-E 3drum BOILERS

6 *features of* C-E 3-DRUM BOILERS

1

Steam discharged from the most active tubes enters the front drum at or above the water line. It therefore passes through little or no water and consequently causes a minimum of turbulence.

2

The front drum, in which most of the steam is liberated, is protected against overloading by reason of the adequate down circulation assured by the number and arrangement of tubes in the second bank. These boilers are inherently free from circulation troubles.

3

Carefully proportioned circulators between the upper drums permit properly balanced water levels. Large water storage capacity and liberal steam release space permit operation at high ratings and provide for sudden steam demands without adversely affecting water level or steam quality.

4

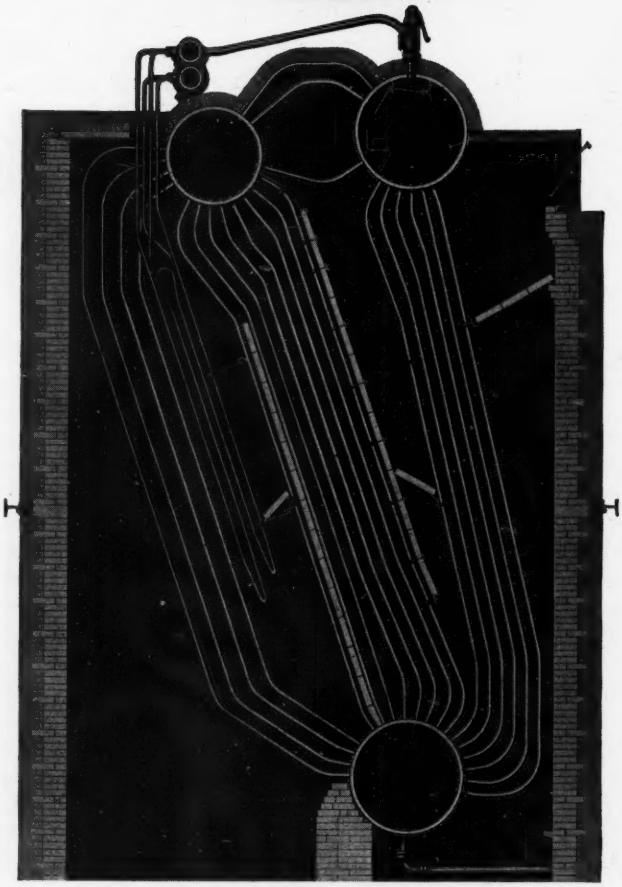
The spacing and arrangement of tubes is such as to assure the maximum heat absorption consistent with moderate draft loss. The design provides adequately for any superheat requirements.

5

The rear drum provides adequate steam space and is equipped with specially designed internals which assure uniform distribution of feedwater and effective separation of entrained moisture.

6

Shape and arrangement of tubes and type of suspension provide maximum flexibility for expansion and contraction of unit.



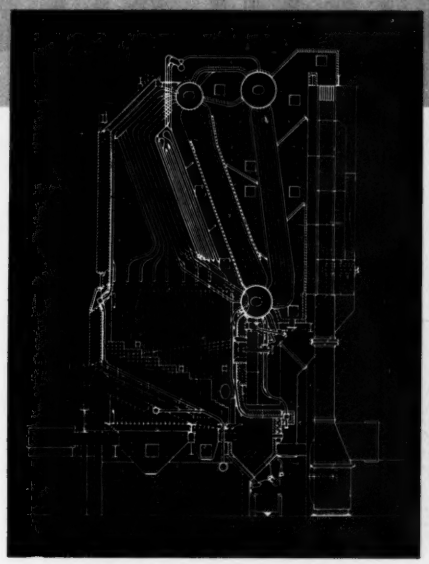
TYPICAL ARRANGEMENT OF
STANDARD C-E 3-DRUM BOILER

Built for capacities from about 25,000 lb per hr up

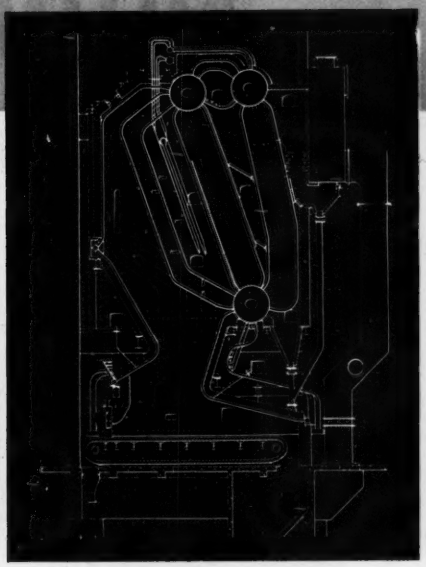
C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

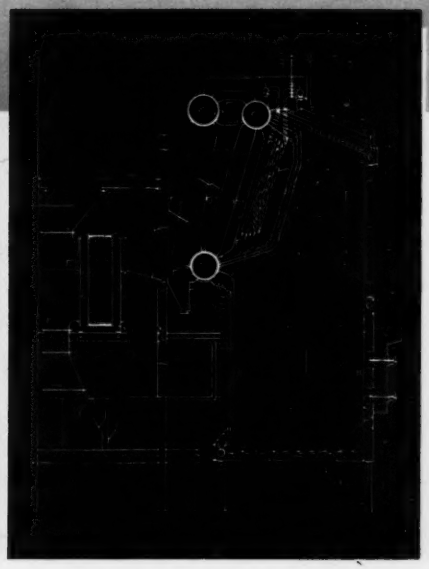
. . . MEET A WIDE RANGE OF REQUIREMENTS



C-E 3-Drum Boiler fired by a multiple retort stoker with auxiliary natural gas burner



C-E 3-Drum Boiler fired by a traveling grate stoker. Water-cooled arches and side walls



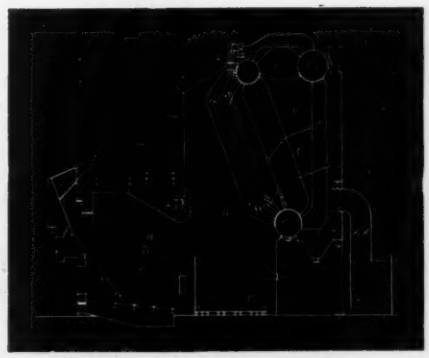
C-E 3-Drum Boiler equipped with burners for firing either oil or pulverized coal

YOUR problem in the selection of steam generating equipment may be character of fuel or load. It may be one of space. Perhaps your preference for a particular type of firing equipment is a factor.

Regardless of any or all of these considerations if you need a unit for a capacity from 25,000 lb. per hr. up, you will find that a C-E 3-Drum Boiler can not only be adapted to your requirements but may be the most suitable design you can buy. You can set it over a furnace of any desired proportions; use vertical or cross baffling; add as much superheater surface as you need—or none at all; use a refractory furnace or water walls; add an economizer or air heater—or both if desired; use whatever type of firing equipment is best suited to the fuel available. When all these points are decided, you will find that a C-E 3-Drum Boiler will fit into the picture and permit the development of a well coordinated overall design exactly suited to your requirements.

The accompanying cross sectional views of actual installations illustrate the complete adaptability of these boilers to units employing various types of fuel burning, superheater and heat recovery equipment.

Quite aside from the adaptability feature, this boiler is outstanding in its design and construction characteristics. It may be counted upon to measure up to the highest standards of modern practice. Some of the reasons for its superiority are summarized on the opposite page. Further information on the C-E 3-Drum and other C-E Bent Tube Boilers is presented in a new catalog. Ask for Catalog BT-6.



C-E 3-Drum Boiler equipped with a Dutch Oven and wood burning grates

A-451

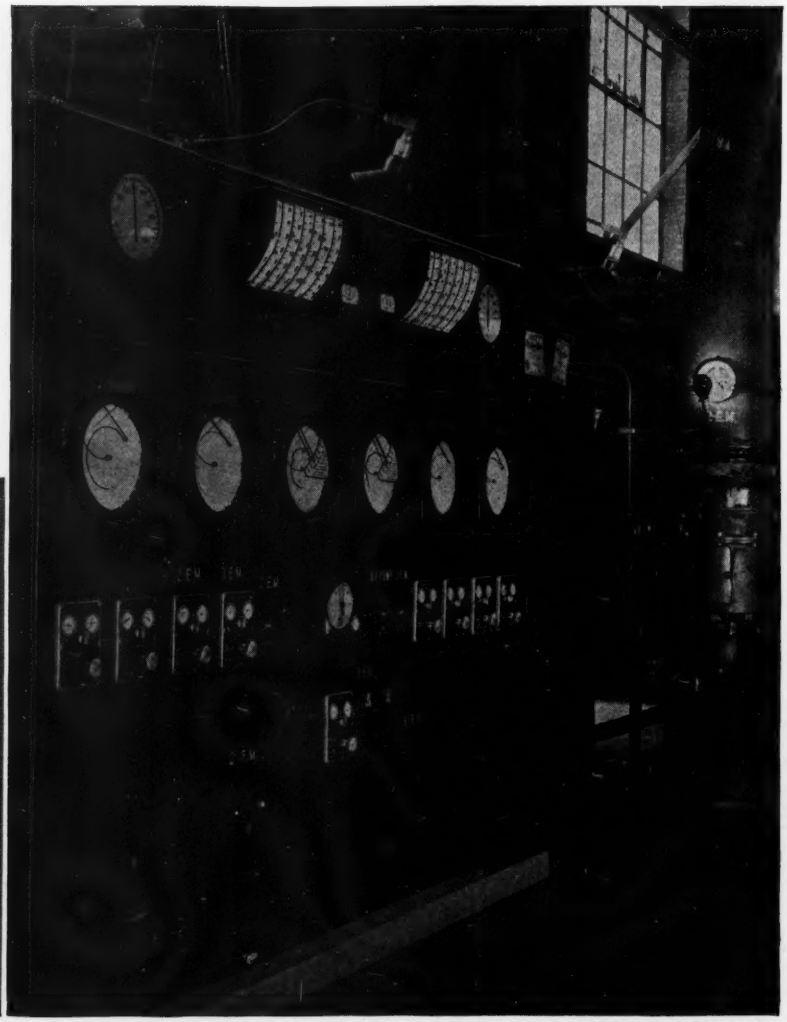
COMBUSTION ENGINEERING COMPANY, INC., 200 MADISON AVENUE, NEW YORK, N. Y. • CANADA: COMBUSTION ENGINEERING CORPORATION, LTD., MONTREAL

ENGINEERING

Complete Combustion

AUTOMATICALLY

Continuous Checking
Bailey Boiler Meter Raises



Bailey Boiler Control Panel for two 80,000 lb. per hour capacity pulverized coal-fired boilers. Each Bailey Boiler Meter (one for each boiler) continuously measures Steam Flow—Air Flow and by means of an air pilot valve automatically readjusts fuel—air ratio to maintain best combustion economy day after day.

BAILEY METER CONTROL . . .

BOILER METERS • MULTI-POINTER GAGES • FLUID METERS • RECORDERS • SUPERHEAT

Control

MAINTAINS *Fuel—Air Ratio*

and Automatic Readjustment by the Monthly Efficiencies to Test Standards

● Like other good combustion control systems, Bailey Meter Control maintains steam pressure, regulates furnace draft and distributes load among boilers; but it does not stop with these usual advantages. It offers a plus value which automatically raises monthly operating efficiencies to test standards. This plus value is automatic readjustment of the fuel—air ratio.

In Bailey Meter Control, nothing is left to the uncertainty of periodic human attention. Fuel—air ratio, the factor which determines fuel economy, is continuously watched and instantly readjusted, when necessary. A sensitive air pilot valve operated by the Bailey Boiler Meter automatically compensates for variations in B.t.u. content of fuel, percentage of moisture in coal, and idiosyncrasies in feeders.

Automatic readjustment of this important ratio completes the combustion control system. It creates a control which stays on the job continuously, to insure economical combustion day after day.

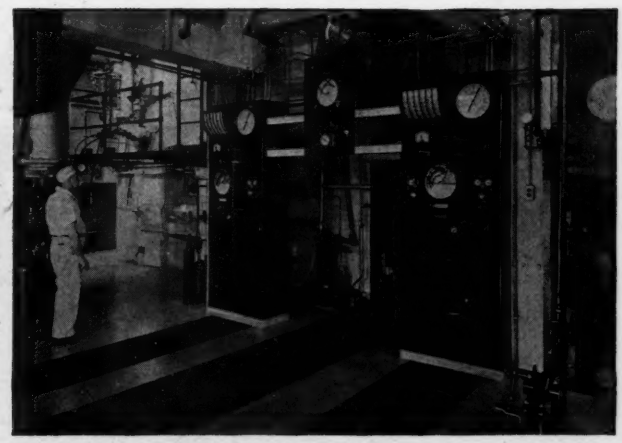
According to actual operating results, fuel savings often return the entire cost of Bailey Meter Control during its first year of operation.

Details of this complete control system will be sent to you upon request. Ask for Bulletin 102-B A-57

BAILEY METER COMPANY • 1040 IVANHOE ROAD • CLEVELAND, OHIO

Bailey Meter Company Limited, Montreal, Canada

This Complete Control System at Riverside Cotton Mills, Danville, Virginia, paid for itself in three months. It allows no combustion losses to exist between visits of operators—Automatic Readjustment of Fuel—Air Ratio by the Bailey Boiler Meter insures continuous combustion economy.

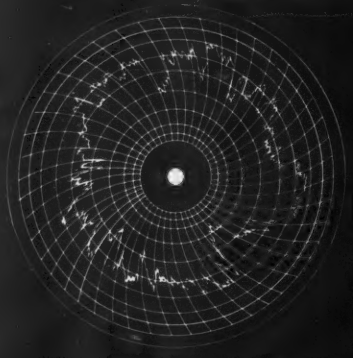


This Complete Combustion Control System, at the American Molasses Co., Brooklyn, New York, returned its cost in ten months. It requires no periodic manual readjustment to maintain maximum combustion economy.

The Complete Combustion Control System

CONTROL • DESUPERHEAT CONTROL • COMBUSTION CONTROL • FEED WATER CONTROL

FLEXIBILITY



20 to 1

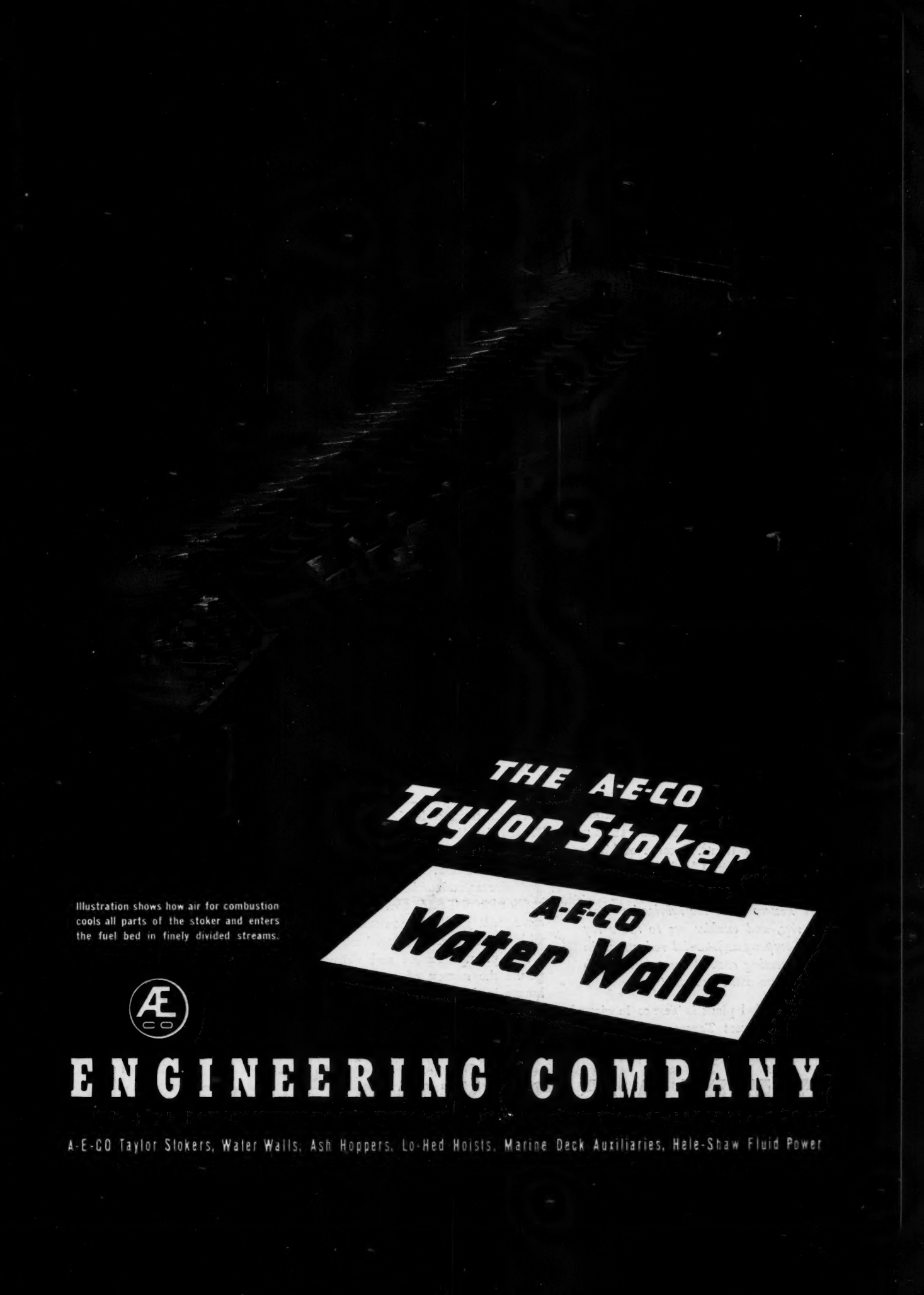
Flexibility—the ability to follow the load up or down without sacrificing efficiency—is a vital factor when selecting fuel burning equipment. Flexibility makes possible a cost saving reduction in the number of units on the line. A-E-CO Taylor Stokers in daily operation are carrying ***efficiently*** loads that vary 20 to 1. The following performances are a matter of actual record: 40,000 lbs. hr. to 300,000 lbs. hr. in 72 seconds; cold boiler, no fire, to 250% rating in 20 minutes . . . Why accept less? Ask the A-E-CO representative to submit proof and show you how you will be benefitted by such performance. American Engineering Co., Aramingo Ave., Philadelphia, Pa.

During the coal strike this Spring, numerous Taylor Stoker owners found it possible to continue operation with anthracite coal when their normal coal supply was cut off.

GET THE FACTS ABOUT

Reliability
Capacity
Maintenance
★ Flexibility
Efficiency
Operation
Adaptability
Fuel Flexibility
Refuse Disposal
Stack Discharge
Space Requirements
Obsolescence

AMERICAN


THE A-E-CO
Taylor Stoker
A-E-CO
Water Walls
Illustration shows how air for combustion cools all parts of the stoker and enters the fuel bed in finely divided streams.
ENGINEERING COMPANY
A-E-CO Taylor Stokers, Water Walls, Ash Hoppers, Lo-Hed Hoists, Marine Deck Auxiliaries, Hele-Shaw Fluid Power

"Substantial Reductions

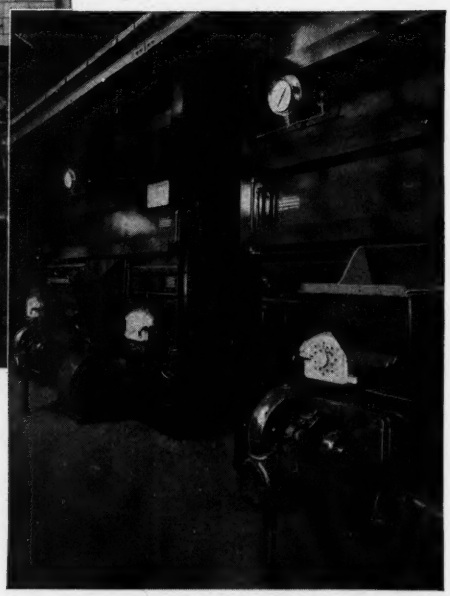
IN OUR OPERATING COSTS"...

says
Chief Engineer
Samson

STEAM-DRIVEN AMMONIA COMPRESSORS in the plant of the Goebel Brewing Co., Detroit. *Switching* to Texaco Lubricants 4 years ago, Chief Engineer Samson has effected a 75% reduction in maintenance cost.

•

Left: **R. J. SAMSON,** Chief Engineer of Goebel Brewing Co. plant, reports that Texaco saves him lubrication worries, and enables him to show substantial reductions in operating costs. He recommends Texaco Lubricants and service.



MODERN BOILER ROOM of the Goebel Brewing Co., Detroit, presided over by Chief Engineer R. J. Samson, shown opposite. Aided by Texaco Lubricants and Texaco Engineering Service, Mr. Samson has shown a power saving of 8%. Naturally, he is enthusiastic for Texaco, based on the results he is getting.

IN 1935, the Goebel Brewing Company power plant in Detroit began to use Texaco Lubricants. Because of his success with them, Chief Engineer R. J. Samson says:

"Texaco saves me lubrication worries, and enables me to show my Company substantial reductions in operating costs. I recommend both Texaco and its service."

The Goebel plant is Texaco lubricated 100%. It uses Texaco steam cylinder oils in the steam ends of its compressors, Texaco Capella in the compressors, and Texaco Regal for gravity circulating external lubrication.

Engineers, trained in the selection and application of Texaco power plant lubricants, will gladly demonstrate savings with Texaco Perfected Lubrication.

For prompt service and deliveries, phone the nearest of our 2279 warehouses in the U. S., or write:

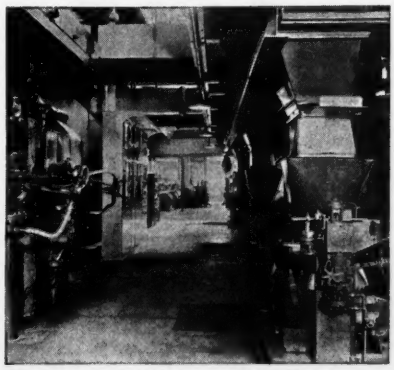
The Texas Company, 135 East 42nd Street, New York, N. Y.

TEXACO

Texaco Dealers invite you to tune in The Texaco Star Theatre—a full hour of all-star entertainment—Every Wednesday Night — Columbia Network — 9:00 E.S.T., 8:00 C.S.T., 7:00 M.S.T., 6:00 P.S.T.

TEXACO Steam Cylinder Oils

STEAM COSTS ARE BEING CUT!



READ HOW THESE INDUSTRIAL PLANTS CUT THEIR STEAM PRODUCTION COSTS

• More steam for less money means increased profits. Read how these industrial plants made their boilers bigger money makers. Some installed new boilers—others revamped existing equipment —but they all installed Smoot Automatic Combustion Control to assure continuous operation at maximum efficiency. Find out if you can make similar savings by modernizing with Smoot Control!

Savings In Maintenance Pay For Controls

• Here is a good illustration of how an average sized plant that cannot afford elaborate remodeling can get the benefits of modern control developments that pay for themselves in hard cash. The chief engineer of a medium sized industrial plant had to get the best possible performance from his existing boiler equipment. Because of furnace design, it was hard to hold steam pressure, there was trouble from smoke and it was difficult to get good regulation of furnace draft and fuel feed. As a result, ignition was sometimes lost and refractories needed unduly large repairs every year. About 14 months ago, instead of paying for furnace rebuilding, which would have been necessary if existing operating methods had been continued, the engineer put the maintenance money into SMOOT control for his two 490-hp. chain-grate stoker-fired boilers. Result—a 50 per cent cut in furnace maintenance. This item alone was enough to pay for the control in 18 months. In addition, the steam pressure is being held constant and the smoke troubles have been eliminated. The complete story is told in folder No. 4-1-39. Write for a copy today if you are faced with a similar problem.

SAVE $950.00 PER MONTH During 7 Months of the Year

• Here is an excellent example of how steam costs can be cut by modernizing a power plant to take advantage of competitive fuel prices. A well-known hospital is now saving $950.00 per month during seven months of the year as a result of its modernization program. The remodeled plant, of 1600-hp. capacity, consists of three boilers burning gas and oil in a combination system. To assure maximum operating efficiency, the three boilers are equipped with a SMOOT combustion control system and REPUBLIC boiler instruments. The control system, in accordance with steam demands, regulates the flow of gas and oil to the burners and automatically maintains proper draft conditions. The complete story is told in folder No. 3-1-37. Write for a copy. Your request involves no obligation.

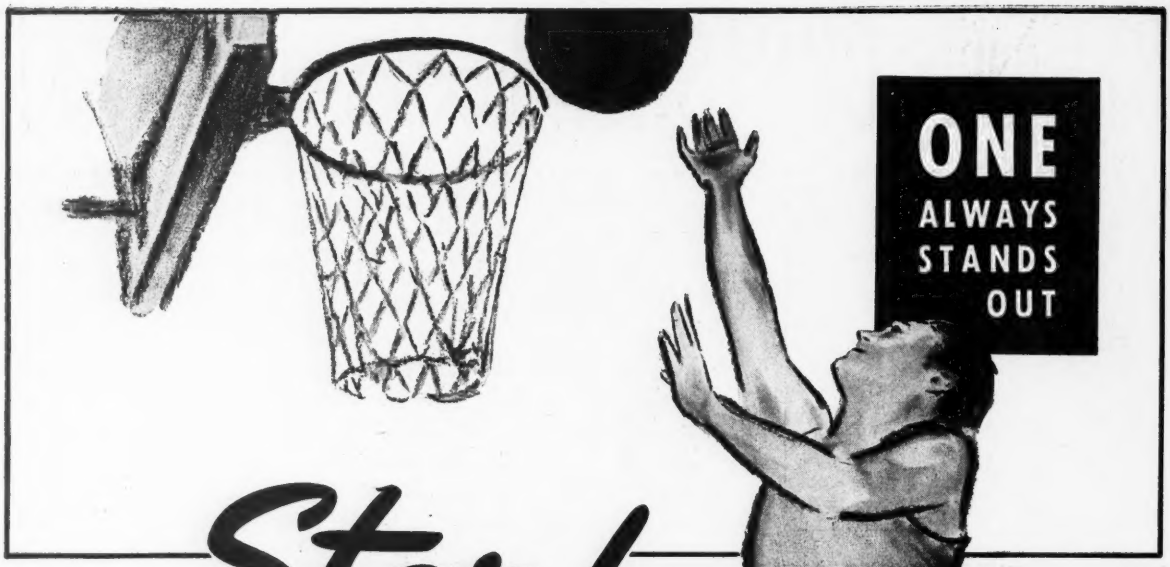
14% INCREASE In Boiler Efficiency

• This paper mill replaced 14 low-pressure boilers with one high-pressure, high-capacity unit under complete automatic control. As a result, boiler efficiency has been raised from 70 per cent to 84 per cent. The savings resulting from this increase in boiler efficiency have more than justified the cost of modernization. The operators attribute part of the success of the new installation to the SMOOT combustion control system. This system enables them to take full advantage of the economies "built into" the new unit. Steam pressure, steam temperature and furnace draft are maintained so constant that they appear as straight lines on the recorder charts. Read the complete story of this typical successful power plant improvement in folder No. 1-24-38.

• LOW STEAM COST is not the result of efficient boiler design alone! It is determined by the degree with which your method of boiler control takes full advantage of those economies which have been "built-in" the boiler!

REPUBLIC FLOW METERS CO.

2224 DIVERSEY PARKWAY CHICAGO, ILLINOIS



ONE
ALWAYS
STANDS
OUT

Star!

AS much of a star in its field as the high scoring basketball player is in his, GARLOCK 777 Rubber and Duck Spiral Packing gives outstanding service against hot or cold water and low pressure steam. If formed rings are desired specify GARLOCK 333.

THE GARLOCK PACKING CO., PALMYRA, N. Y.

In Canada: The Garlock Packing Co. of Canada Ltd., Montreal, Que.

GARLOCK 777

LOOK WHAT HAPPENED TO TURBINE RECORDS HERE!

• JUST ONE CHANGE was made, a shift to Nonpareil Turbine Oil, and look what happened to turbine oil records in a Kansas industrial power plant.

Here's the record of two 3-year periods. The first period consisted of approximately 20,000 hours operation on various turbine oils. The second period was on the same turbine, under similar operation, but with Nonpareil Turbine Oil.

Item	1st Period Various Oils	2nd Period Nonpareil
Complete Fill of Oil	3	1 (Original)
Make-up Oil	850 Gals.	250 Gals.
Cleaning Oil System	5 times	0
Batch Treatment	2 times	0

The saving in maintenance and actual oil costs will soon pay for the higher quality Nonpareil, and then this saving *continues* for the *life of the turbine.*

Let a Standard Lubrication Engineer explain why this oil *alone* is *guaranteed* for the life of your turbine, and how that guarantee can save money and avoid trouble for you.

You can reach one of these Engineers through your local Standard Oil (Indiana) Office, or by writing 910 S. Michigan Avenue, Chicago, Illinois.

FIRST IN SERVICE FOR FIFTY YEARS STANDARD OIL (Ind.)

Copr. 1939, Standard Oil Co. (Ind.)

NONPAREIL TURBINE OIL

CATION ENGINEERING...LUBRICATION ENGINEERING...LUBRICATION ENGINEERING...LUBR

NGINEERING...LUBRICATION EN

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

FIRST CLASS PERMIT No. 252 (SEC. 510 P. L. & R.) CHICAGO, ILLINOIS

STANDARD OIL COMPANY (Ind.)

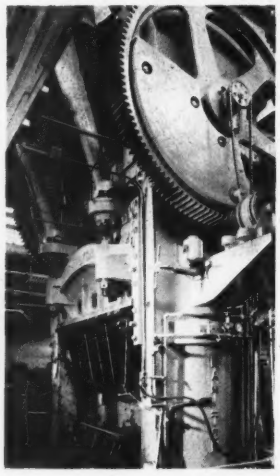
910 S. MICHIGAN AVENUE

Mr. W. I. Nunn
Room 1220

CHICAGO, ILL.

ENGINEERING • • LUBRICATION ENGINEERING • • LUBRICATION ENGINEERING • • LUBRICATION

Above: Spindle bearings on a cheese box machine in a Wisconsin plant, in which Superla Grease eliminated high consumption, leakage, and bearing failure



SUPERLA GREASE

Changing to Superla 2X grease for plain and anti-friction bearings saved about 50% in lubricating costs at the Metal Auto Parts plant in Indianapolis.

Superla 2X is used on the cups in the large forming presses. Superla No. 39 has proved "very satisfactory" in the centralized lubricating systems on these same presses after several years of operation.

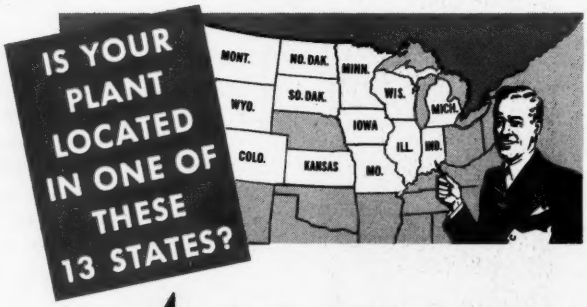
It's a simple matter to find out whether you are getting rock-bottom cost in grease lubrication. Let a Standard Lubrication Engineer test Superla on just one bearing in your plant. It won't cost you a cent—you may save plenty.

KEEPS DIRT OUT KEEPS BEARINGS IN

On its first trial Superla Grease was given the job of lubricating the bearings on the box machine spindles shown above.

Before Superla was used, these bearings failed frequently. Excessive leakage and high consumption were also serious problems. With Superla, less grease is needed for adequate lubrication. It stays in the bearings and dirt stays out. And bearing failures stopped.

There's a Standard Lubrication Engineer at your service at any time to help you with bearing or other lubricating problems. Call your local Standard Oil (Indiana) office or write 910 South Michigan Avenue, Chicago, Illinois.



GET THIS NEW LITERATURE

Two new interesting booklets on lubrication are available to all plant men in the 13 States shown on the map above.

"Spare the Time to Spare Your Machines," describes the latest development in a highly stable, long-lasting oil for many uses.

"How StanoCyl Cuts Oil Consumption," should be of interest to all power plant men concerned in the purchase or use of steam cylinder oil.

"The Lubrication Engineer—His Value to You," tells how these Engineers work and what they can do to help you reduce lubricating costs throughout your plant.

Check the subjects that interest you and mail the card. No postage is necessary.

STANDARD OIL COMPANY (Indiana) DECEMBER

910 S. Michigan Avenue, Chicago, Illinois.

Gentlemen: I am in one of your 13 Middle Western States.

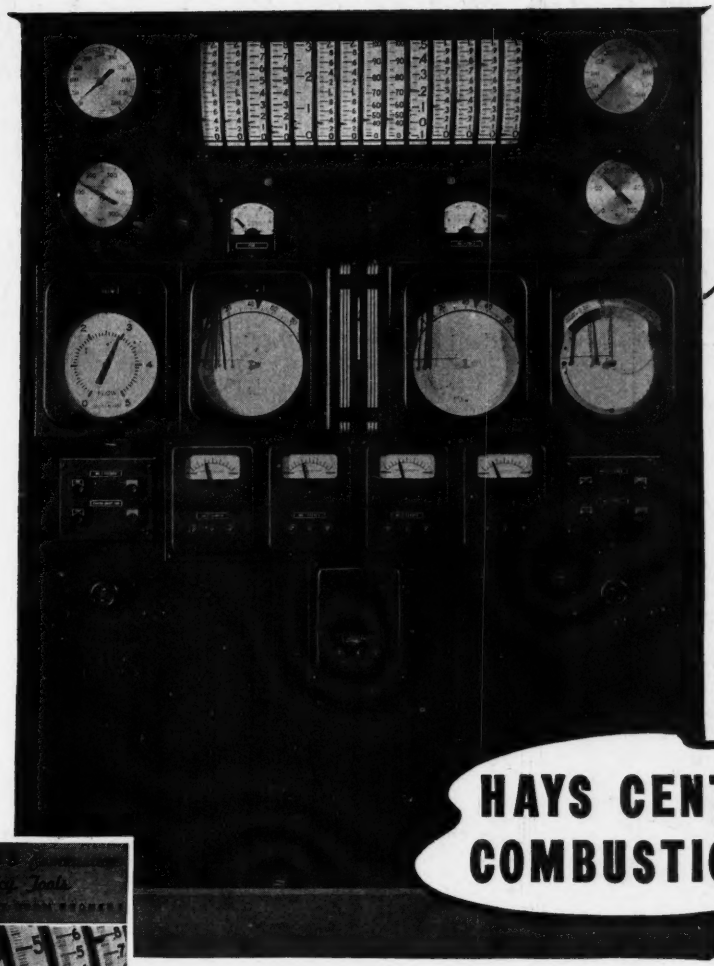
- ☐ Have your Engineer call.
- ☐ Do not have your Engineer call, but please send me the booklet (s) checked:
- ☐ "Spare the Time to Spare Your Machines."
- ☐ "How StanoCyl Cuts Oil Consumption."
- ☐ "The Lubrication Engineer—His Value to You."

Name ..... *Position* .....

Company .....

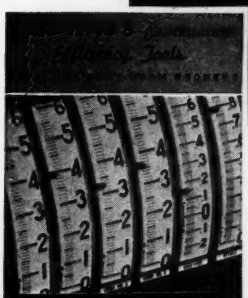
Address .....

City ..... *State* .....

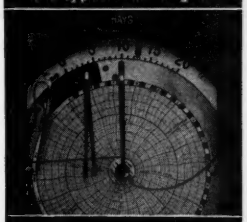


Lower
STEAM COST
More Perfect
COMBUSTION
Steadier
POWER
through

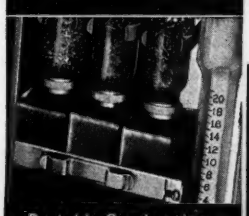
HAYS CENTRALIZED COMBUSTION CONTROL



Draft Gages
all types and ranges



Combustion Meters



Portable Combustion
Testing Instruments

HAYS centralized automatic combustion control is adapted to steam power plants of all sizes burning all types of fuel. Its benefits are positive—steam is produced at the lowest possible cost, it is held at a constant pressure regardless of load. Combustion is maintained at its highest efficiency, which means less smoke, cleaner boiler tubes, better heat absorption, lower maintenance.

Hays is the one truly CENTRALIZED control system—ALL of the control units and measuring instruments are contained in one panel. Here is concentrated all of the information necessary for an intelligent understanding of what is going on inside furnace, boiler and steam lines. And from this central panel the entire control system or any individual part of it may be operated manually.

The Hays system is extremely sensitive—responding to ounces of change in steam-header pressure. Electrically operated the response is instantaneous —corrections made with no lagging.

Hays Centralized Combustion Control is offered through capable engineering organizations located in all the principal cities of the U. S. A. and Canada. Correspondence is invited. Send for 40-page catalog.

The HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

As More High Pressure

YARWAY UNIT TANDEMS

Pressures from 600 lbs. to 2500 lbs.

A Seatless and Hard-Seat Valve combination using a one-piece forged steel billet as a common body for both valves. Flanged forged steel inlet and outlet nozzles are screwed and welded into this billet. Nitralloy and stainless steel trim.

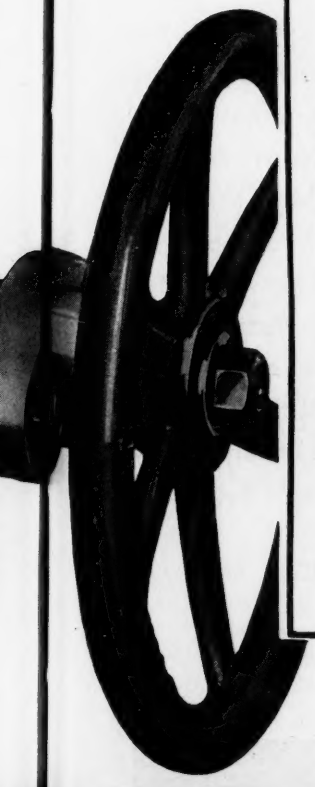
Outside sealing valve is the familiar Yarway Seatless design. Inside (next to boiler) blowing valve is a new Yarway Hard-Seat Valve utilizing special alloys and unique construction features which materially reduce normal wear in this type of valve.

YARWAY

Plants Are Built . . .

YARWAY GOES ALONG

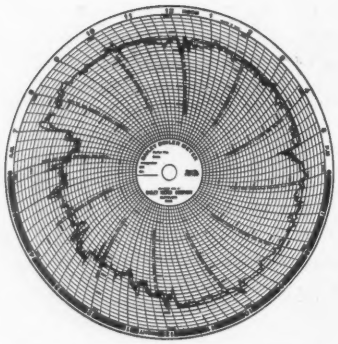
	VALVE DESIGN PRESSURE
PHILADELPHIA ELECTRIC COMPANY Schuylkill Station—Phila., Pa.	**1400 lbs.**
BOSTON EDISON COMPANY Boston, Mass.	**1400 lbs.**
PACIFIC GAS & ELECTRIC COMPANY Avon and Martinez, Calif.	**1500 lbs.**
PUBLIC SERVICE ELECTRIC & GAS CO. Essex Station, Newark, N. J.	**1400 lbs.**
NEBRASKA POWER COMPANY Omaha, Nebraska	**1500 lbs.**
STANDARD OIL CO. OF CALIFORNIA Richmond, Calif.	**1500 lbs.**
GULF STATES UTILITIES COMPANY Chaison, Texas	**1500 lbs.**
COLUMBUS RWY., LIGHT & POWER CO. Groveport, Ohio	**1475 lbs.**
SOUTHERN ALKALI CORPORATION Corpus Christi, Texas	**1500 lbs.**
MADISON GAS & ELECTRIC COMPANY Madison, Wisconsin	**975 lbs.**
DALLAS POWER & LIGHT COMPANY Dallas, Texas	**900 lbs.**
BROOKLYN-MANHATTAN TRANSIT CO. Brooklyn, New York	**975 lbs.**
HARTFORD ELECTRIC LIGHT COMPANY Hartford, Conn.	**900 lbs.**
HUMBLE OIL & REFINING COMPANY Baytown, Texas	**900 lbs.**
CONN. LIGHT & POWER COMPANY Montville, Conn.	**900 lbs.**
PITTSBURGH PLATE GLASS CO. Columbia Chemical Div., Barberton, Ohio	**900 lbs.**
(In addition **YARWAY VALVES** *for* **1855 lbs.** *pressure recently have been built for Installation at six different locations.)*	**1855 lbs.**



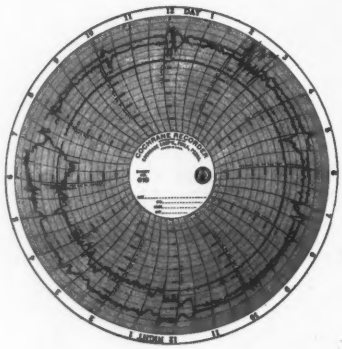
Write for Catalog No. 430. Sent on request.

YARNALL-WARING COMPANY, 114 Mermaid Avenue, Philadelphia

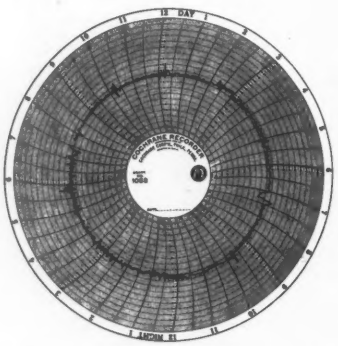
BLOW-OFF VALVES



Steam-flow-air-flow chart shows a typical day's load on The Derby Gas & Electric Company's Integral Furnace Boiler. Rated capacity is 125,000 pounds of steam per hour.

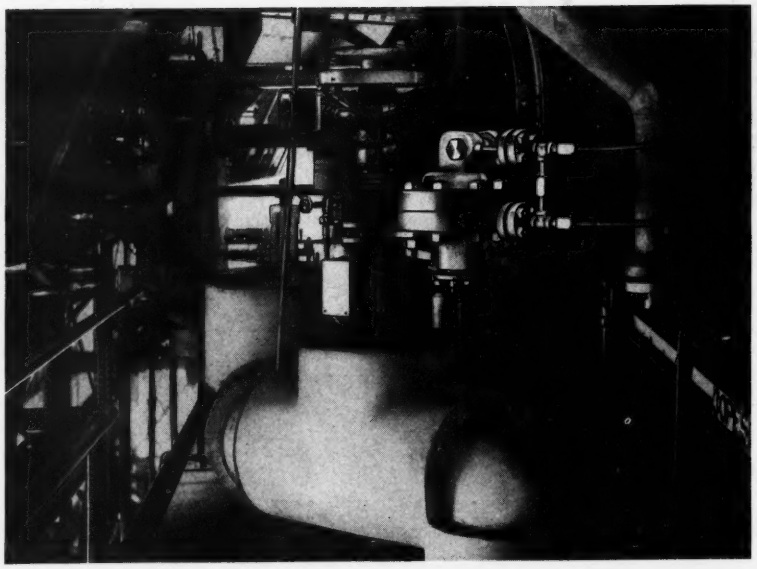


Water flow, middle curve, follows load accurately despite changes in water pressure, outer curve, while steam pressure, inner curve, holds constant at 675 pounds gage.



Water level is stabilized within close limits throughout the day. Maximum variation is only plus or minus one inch, with level rising slightly as load increases.

More than 100 COPES Flowmatics are giving good results on boilers from 130 to 1325 pounds W.S.P. For a complete description of this simplified steam-flow type feed water regulator, write for Bulletin 409-B.



Derby Gas & Electric Co.

"repeats" with COPES Flowmatic

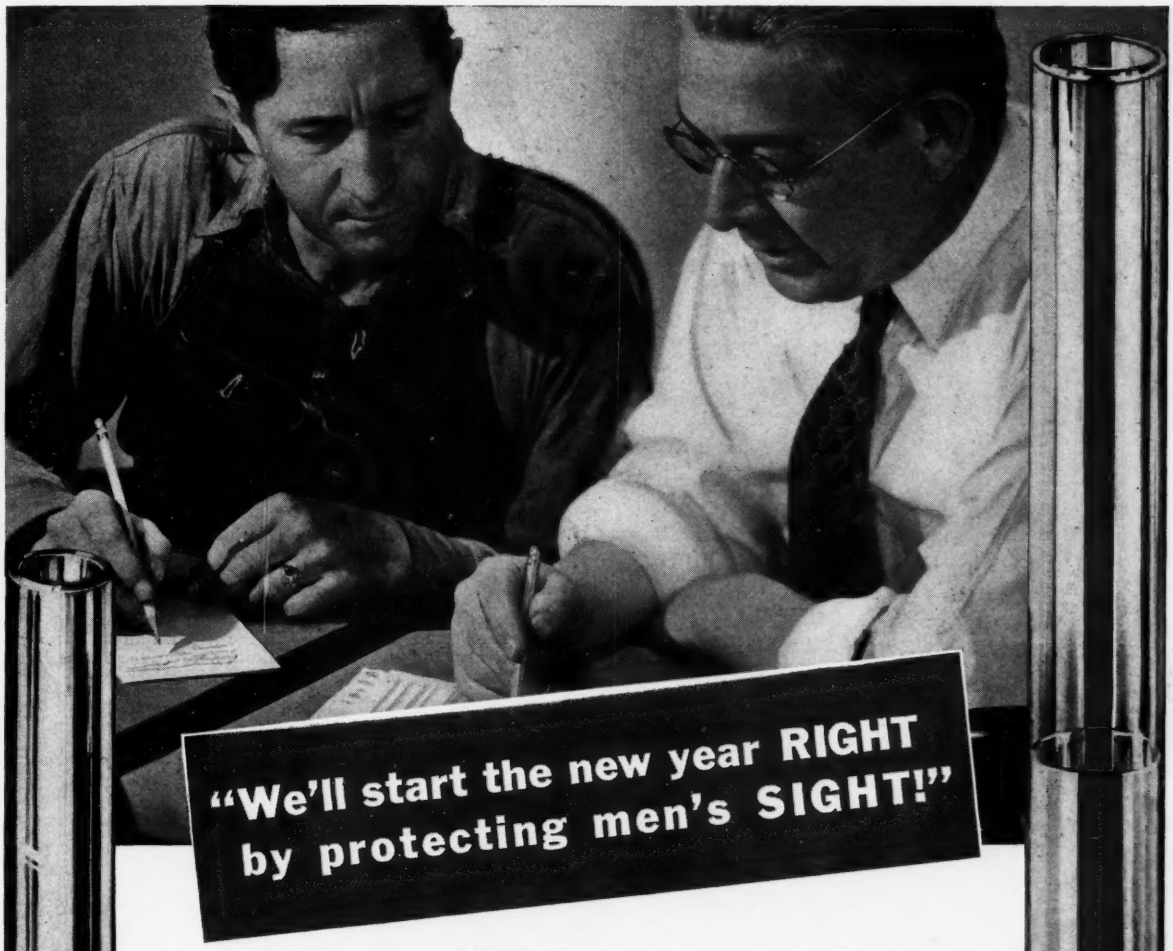
Promises might sell a first order, but no progressive utility repeats with any equipment unless it has made good on the job. And The Derby Gas & Electric Company re-ordered COPES Flowmatic only after checking results of the first installation, shown above, on a 675-pound B. & W. Integral Furnace Boiler. Right from the start, water level has been held within plus or minus one inch. Feed flow has been exactly as needed for the loads. And the COPES Flowmatic has given these aids to safer, more efficient operation without offering any operating or maintenance problem of any kind. For proof of performance, check the charts at the left. For effective feed and level control on your modern boiler, specify the simplified two-element COPES Flowmatic Regulator.

NORTHERN EQUIPMENT CO., 1212 GROVE DRIVE, ERIE, PA.

Feed Water Regulators, Pump Governors, Differential Valves
Liquid Level Controls, Reducing Valves and Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY AND ITALY
REPRESENTATIVES EVERYWHERE

★ GET CLOSER LEVEL CONTROL WITH THE COPES FLOWMATIC ★ REGULATOR



"We'll start the new year RIGHT by protecting men's SIGHT!"

"WE'RE through worrying about what may happen if a boiler gauge glass lets go under the strain of high pressures and sudden changes of temperature. We've resolved to do what we can to protect our boiler room attendants against the scalding steam and flying glass which may result from gauge blowouts. We're starting the year right by protecting sight. We're fitting all boiler water columns with SONDERGLASS."

Just as a popular make of automobile tire inner tube offers double safety through double construction, SONDERGLASS is built with two layers of glass made from semi-metallic substances with different degrees of expansion. Because of this construction feature SONDERGLASS is virtually unaffected by sudden temperature changes and is particularly resistant to steam pressure. Many users call it "the unbreakable gauge glass." It also resists clouding and corrosion, gives notably long and economical service.

Decide to stop gambling with men's eyesight in your boiler room. One poor fellow blinded or mutilated for life may cost you a thousand times more than the slight expense to see that every water column glass in your plant is SONDERGLASS.

Order from your supply house or directly from us.

A. W. CHESTERTON CO., 64 India St., Boston, Mass.

So That Men May See With Safety—

Two glass layers made of semi-metallic substance of different degrees of expansion fused into one strong SONDERGLASS tube. The inside of the tube expands in proportion to the temperature of the steam or hot water and the outside according to the temperature of the air, so that it resists the effect of sudden cold drafts.

SONDERGLASS comes in two popular types: (1) At left, CLEAR Sonderglass for use where water column is well lighted; (2) Above, REFLECTING Sonderglass with a back of red and white enamel that makes the water level stick out like a sore thumb.

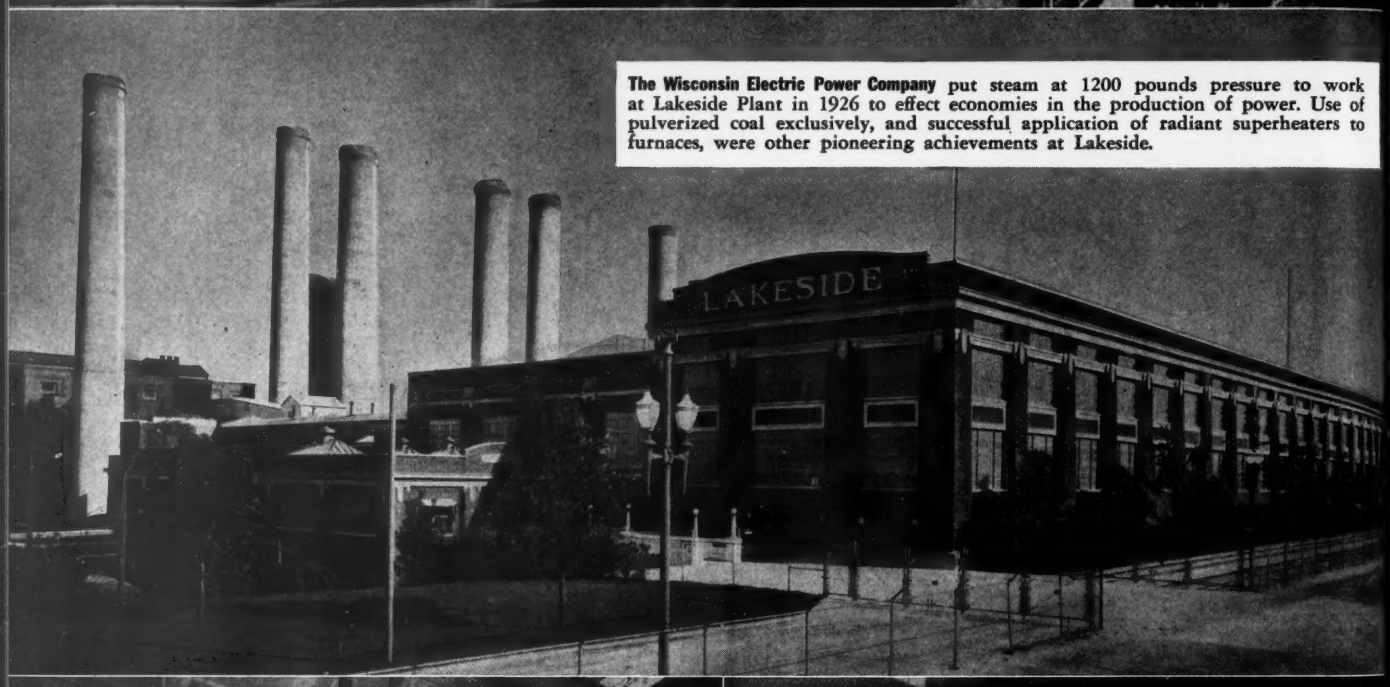
Clear Sonderglass

SONDERGLASS

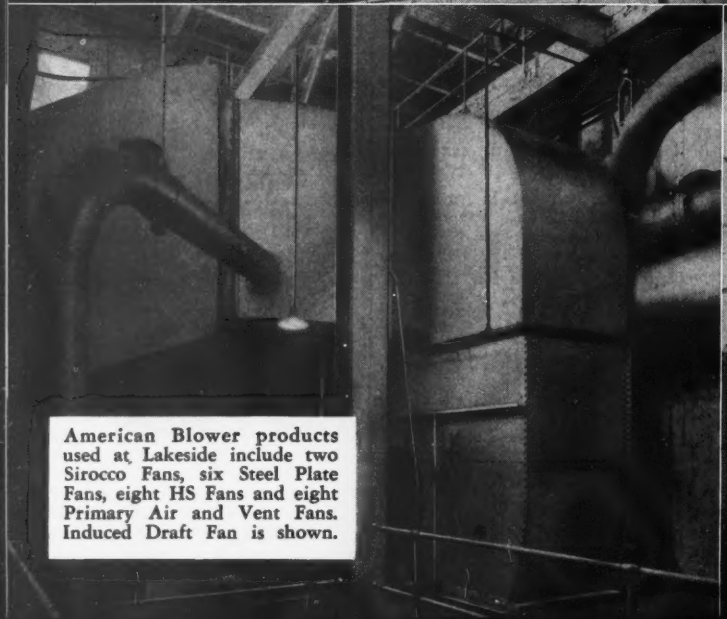
"the unbreakable gauge glass"

MORE

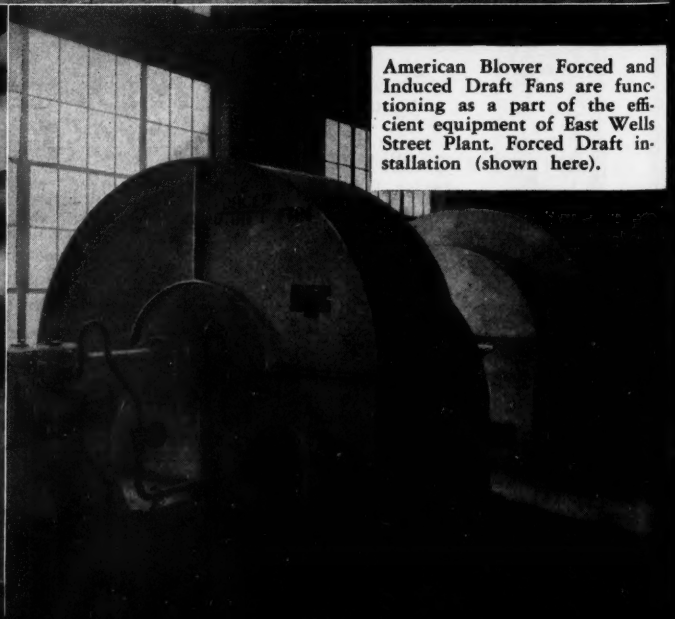
TO SERVE AG



The Wisconsin Electric Power Company put steam at 1200 pounds pressure to work at Lakeside Plant in 1926 to effect economies in the production of power. Use of pulverized coal exclusively, and successful application of radiant superheaters to furnaces, were other pioneering achievements at Lakeside.

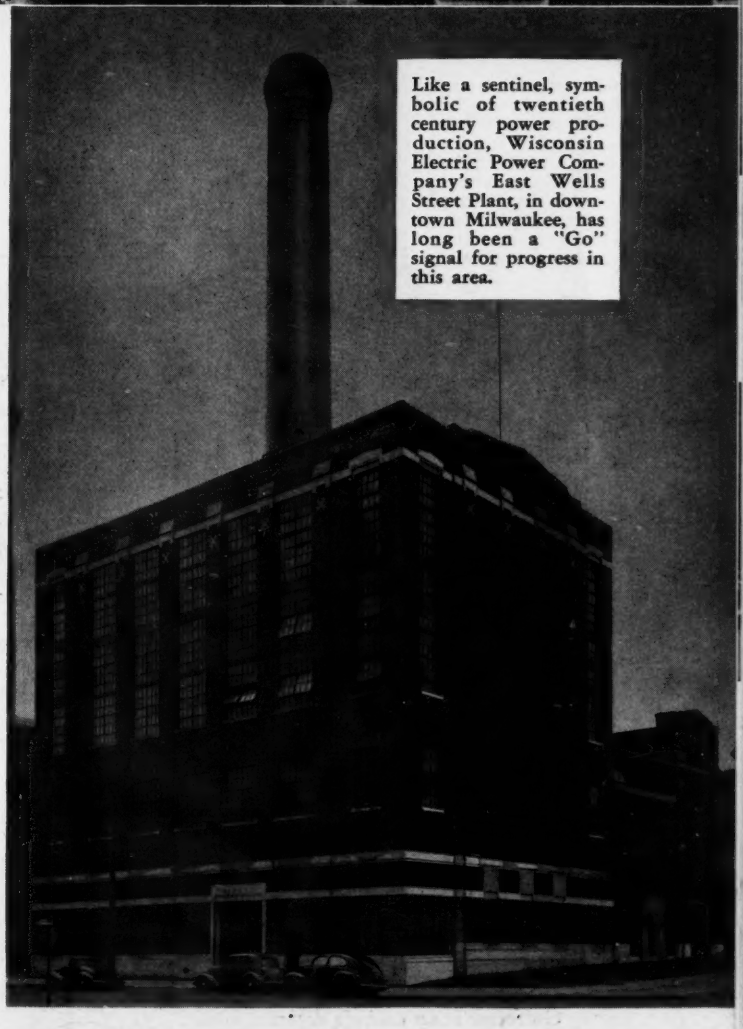


American Blower products used at Lakeside include two Sirocco Fans, six Steel Plate Fans, eight HS Fans and eight Primary Air and Vent Fans. Induced Draft Fan is shown.



American Blower Forced and Induced Draft Fans are functioning as a part of the efficient equipment of East Wells Street Plant. Forced Draft installation (shown here).

THE WISCONSIN ELECTRIC POWER COMPANY, one of America's outstanding public utilities, has long been a leader in reducing the cost of power production. By utilizing modern methods and facilities . . . by sound expansion . . . and by pioneering the development and application of equipment to increase efficiency, this progressive company has cut the cost of power to serve a great, growing community. Most striking evidence of the remarkable advances in plant efficiency is the reduction of heat units required to produce a kilowatt hour—from 25,000 BTU/KWH net in 1922 to only 13,700 BTU/KWH in 1938. American Blower derives great satisfaction from the knowledge that many of its products — including Forced Draft Fans, Sirocco and Steel Plate Induced Draft Fans, Primary Air and Vent Fans—are constantly contributing their full measure of trouble-free, efficient service to the over-all efficiency of this great system. Our Engineers will be glad to cooperate with you, too, in the selection or application of American Blower Mechanical Draft equipment and Fluid Drives (Hydraulic Couplings) for your own plant. Phone, wire or write the nearest American Blower branch office today for complete information.

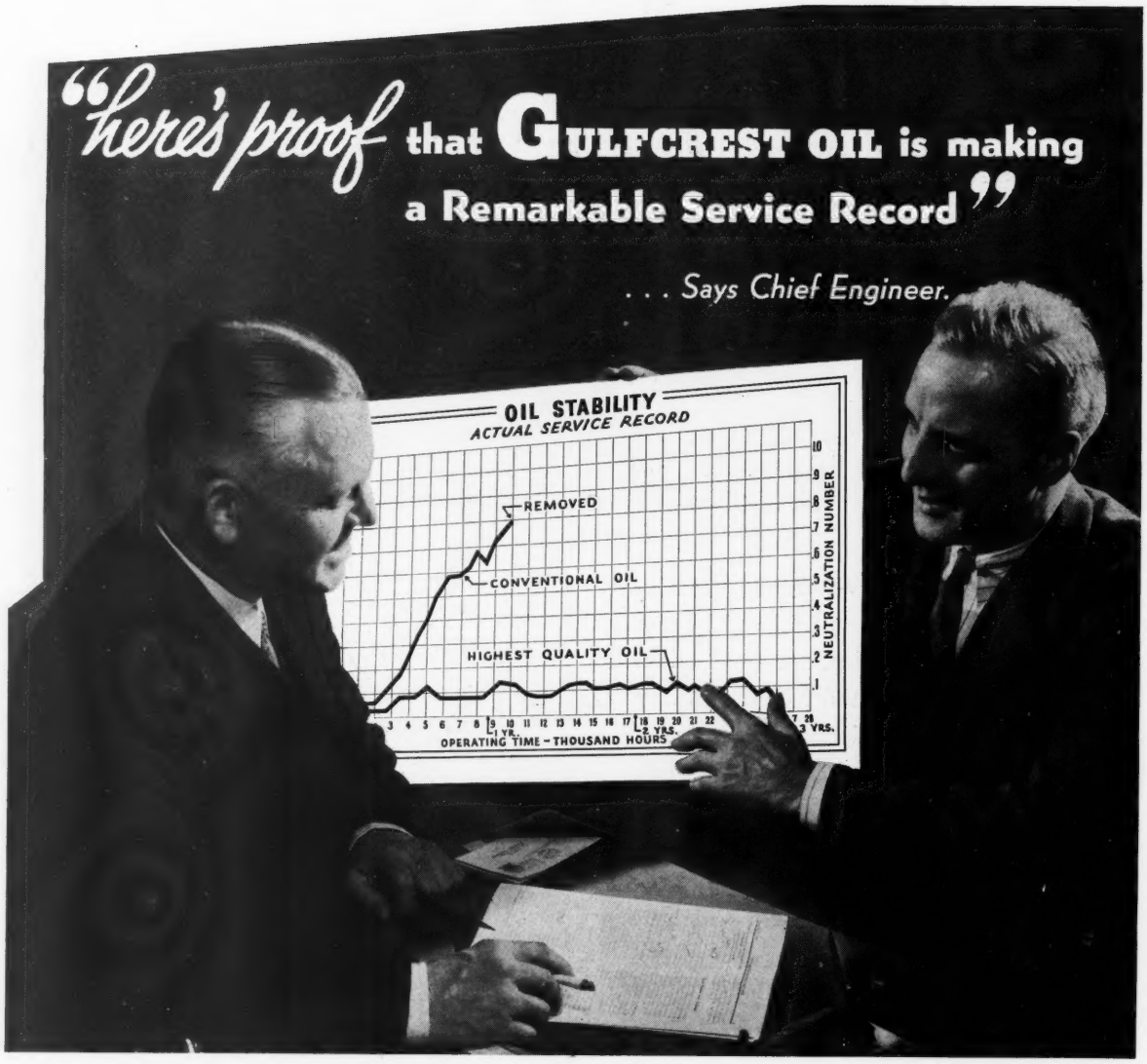


Like a sentinel, symbolic of twentieth century power production, Wisconsin Electric Power Company's East Wells Street Plant, in downtown Milwaukee, has long been a "Go" signal for progress in this area.

AMERICAN BLOWER CORPORATION

6000 RUSSELL STREET, DETROIT, MICHIGAN

Division of American Radiator and Standard Sanitary Corporation • In Canada: Canadian Sirocco Company, Limited, Windsor, Ontario



. . . Service Records prove *GREATER STABILITY* of this Quality Turbine Oil

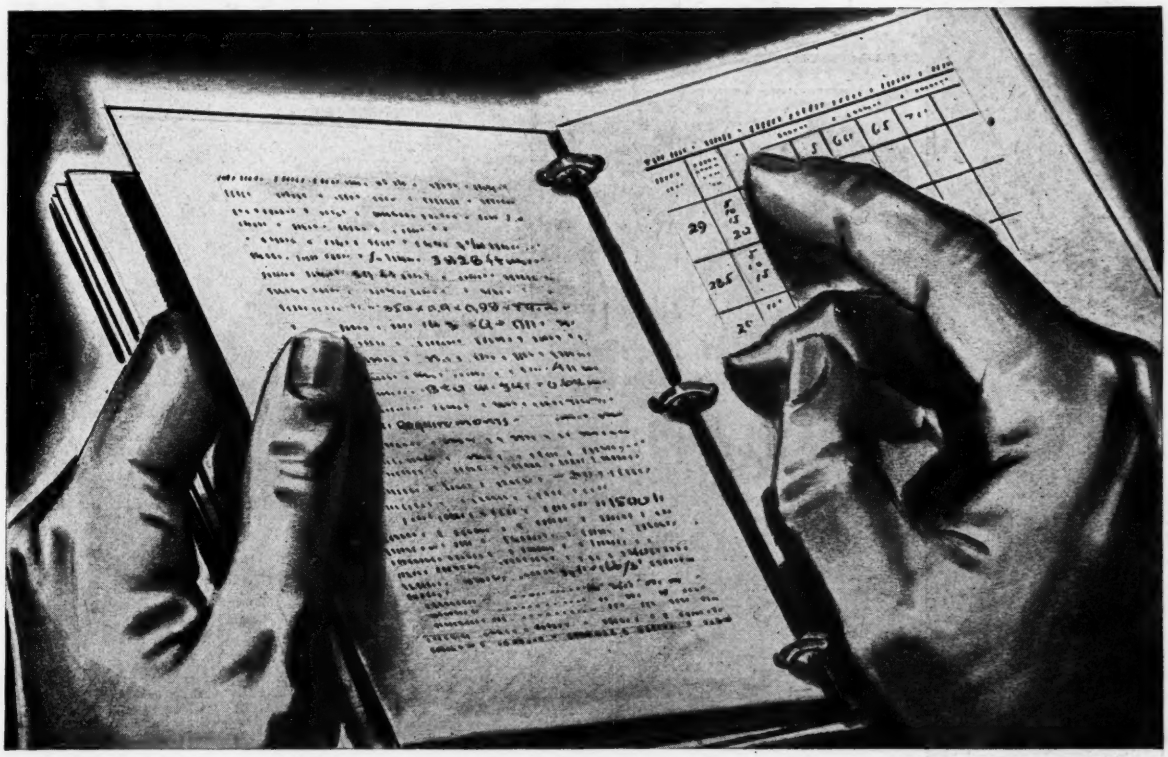
OPERATING data covering the performance of Gulfcrest Oil in major turbine installations throughout the country are verifying daily the fact that this improved type of turbine lubricant possesses remarkable stability. After years of service, Gulfcrest shows so little evidence of deterioration that operators find it is in as good condition as when first put into the system.

Gulfcrest is an *entirely different kind* of turbine oil—for this reason: It has been refined not only by conventional processes, but by Gulf's Alchlor process, an advanced method developed by Gulf refinery technologists for removing undesirable hydrocarbons and other impurities which cause oxidation and sludge formation. As a result of this extra purifying process, Gulfcrest Oil possesses a higher degree of stability than any turbine lubricant of which we have record.

We suggest that you talk with the Gulf engineer about this remarkable turbine oil at your first opportunity. He will be pleased to give you complete details—and you will be under no obligation . . . Gulf Oil Corporation—Gulf Refining Company, Gulf Building, Pittsburgh, Pa.

GULF INDUSTRIAL LUBRICATION

There's No Formula In Your Handbook
FOR PICKING A CONDENSER TUBE ALLOY



. . . BUT A BRIDGEPORT ENGINEER CAN HELP YOU

You can find plenty of information on condensers and heat exchangers in trade publications, reference files, and engineering data books—but you will not find a formula for selecting the tube alloy.

Water velocity, temperature, turbulence, corrosive agents—these and a host of other interlocking factors affect your choice. They vary in every plant—and they cannot be compressed within the rigid limits of a formula. But *experience* in the application of tube alloys can interpret these factors where formulas fail—can supply the gap in your handbook's data.

That is why a Bridgeport engineer can help you with your tube problem. Through his years of field surveys of every type of condenser and heat exchanger, he has acquired the broad background of experience that he will apply to a study of your specific operating conditions. His first-hand knowledge of the performance of Bridgeport alloys will guide him in recommending the one that will serve you most efficiently. It may be Admiralty—low in price, and often satisfactory in normal service. It may be Cuzinal* (Aluminum Brass) or Duronze* IV (Aluminum Bronze)—alloys engineered by Bridgeport for the severe corrosive conditions so often encountered today. Consult with a Bridgeport engineer before you select an alloy for new or retubing jobs. Let his specialized knowledge assist you in making the choice that will give you greatest over-all economy.

*Trade-name

"Bridgeport" BRASS CO.

BRIDGEPORT BRASS

BRIDGEPORT BRASS COMPANY • BRIDGEPORT, CONN. • ESTABLISHED 1865

WRITE FOR YOUR COPY

BRIDGEPORT BRASS COMPANY,
Condenser Tube Engineering Dept. C,
Bridgeport, Conn.

☐ I'd like to have a copy of the new revised "Condenser Tube Manual."

☐ I'd like to talk to one of your condenser engineers about my problem.

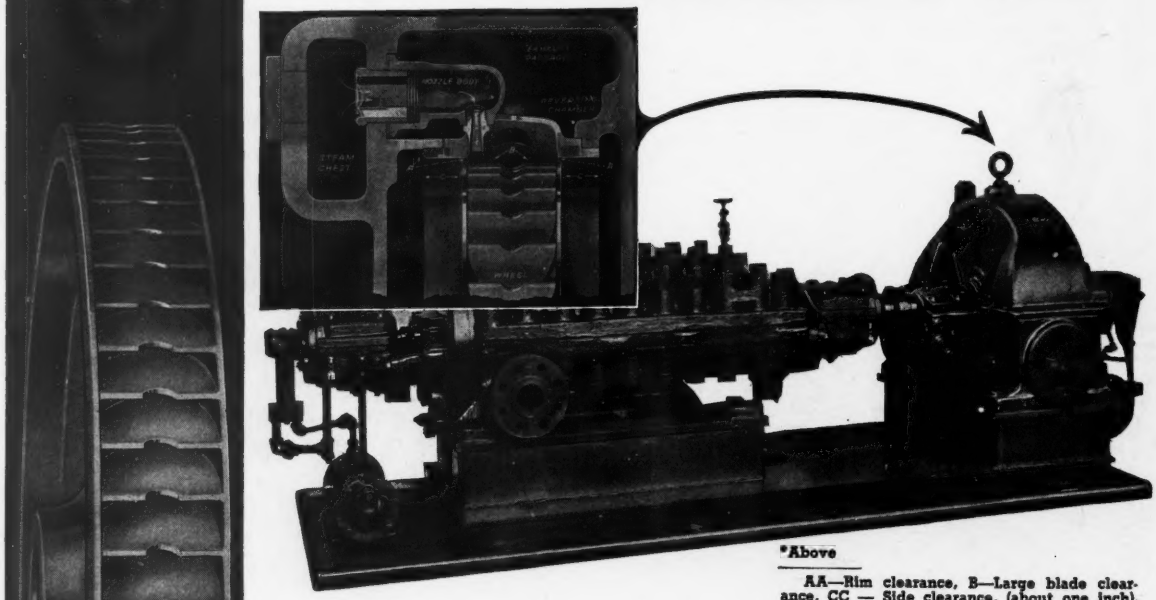
NAME .....

COMPANY ..... TITLE .....

ADDRESS .....

CITY ..... STATE .....

TERRY



*Above

AA—Rim clearance, B—Large blade clearance, CC — Side clearance, (about one inch). Blades cannot foul, as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large that end-play from excessive external thrust cannot damage wheel.

END PLAY WILL NOT DAMAGE THE BLADING OF THE TERRY WHEEL TURBINE

In the Terry Wheel Turbine the blades are protected by rims at the sides of the wheel, which would take without damage any rubbing that might occur if the clearance became reduced. With this construction it is impossible for the blades to foul and frequent inspection of the thrust bearing is not required to obtain safe and dependable operation.

The Terry Wheel Turbine is fully described in our Bulletin S-116. A request on your business letterhead will bring a copy.

T-1133

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Order from Your Nearest Distributor as Listed Below:

IN THE UNITED STATES

"RPM" DELO:
The California Company (Montana only)
Humble Oil & Refining Company
Standard Oil Company (Indiana)
Standard Oil Company (Nebraska)
Standard Oil Company of California
Standard Oil Company of Texas
Utah Oil Refining Company

Diol "RPM" DELO:
The Carter Oil Company, Tulsa, Oklahoma
Colonial Beacon Oil Company
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey
Standard Oil Company of Pennsylvania

Kyso "RPM" DELO:
Standard Oil Company (Inc. in Kentucky)

Signal "RPM" DELO:
Signal Oil Company

Sohio "RPM" DELO:
The Standard Oil Company (Ohio)

IN CANADA AND NEWFOUNDLAND

Imperial "RPM" DELO:
Imperial Oil Limited

IN BRITISH COLUMBIA AND ALBERTA

"RPM" DELO:
Standard Oil Company of British Columbia Limited

THROUGHOUT THE WORLD

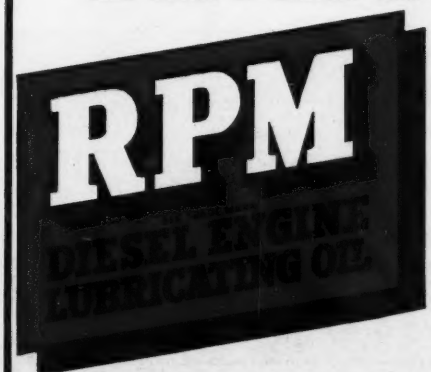
"RPM" DELO is available through distributors in more than 100 countries.

CASE TRACTORS are great performers—have been for 47 years. So when New "RPM" DELO comes through extensive factory tests with the verdict—

"Satisfactory for Case Tractors operating on any fuel from gasoline to tractor fuel or distillate"—

This means it delivers cost-cutting, life-lengthening, profit-raising lubrication! Results of J. I. Case Company tests show: Combustion chambers free of carbon deposits—meaning cooler, smoother, sweeter-running engines! All rings free in the piston grooves. Blow-by and engine wear minimized—full-power performance assured. *Unfailing protection! Longer engine life!*

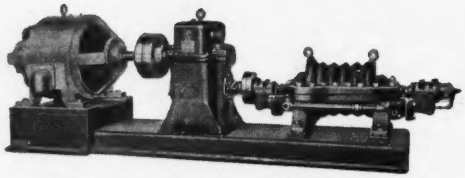
Profit by New "RPM" DELO in *your* equipment—in stationary, automotive, or marine service. It ends ring sticking. It's safe for *all* types of bearings.



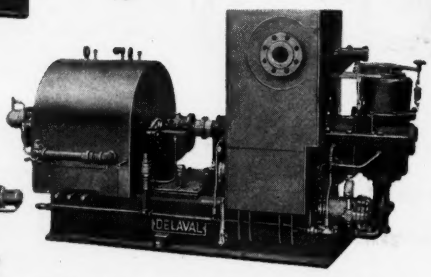
New "RPM" Diesel Engine Lubricating Oil now available everywhere in the gray barrel with the blue head

STANDARD OIL COMPANY OF CALIFORNIA

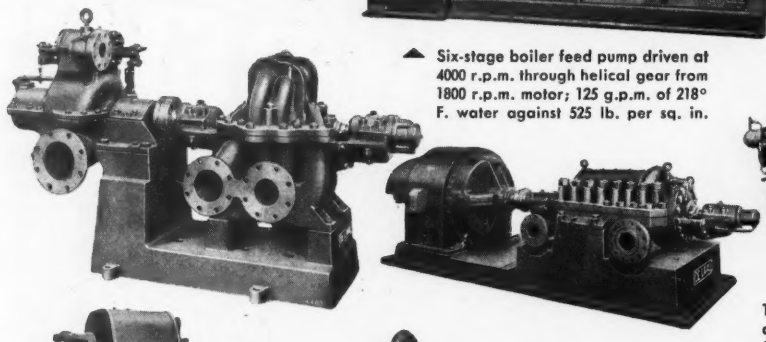
Turbine-driven two-stage series pump; 1000 g.p.m. of 210° water against 350 lb. gage at 3500 r.p.m. The turbine receives steam at 270 lb. gage with 50° F. superheat and exhausts against 60 lb. back pressure.



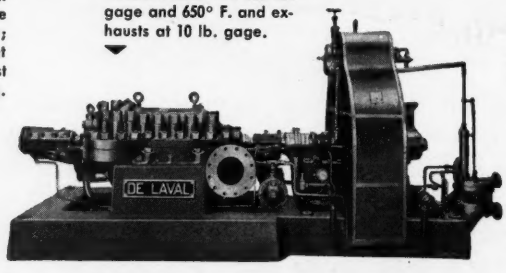
One of 24 turbine-driven boiler feeders for new 18-knot bulk oil tankers; 300 g.p.m. each of 235° F. water against 575 lb. per sq. in. at 4000 r.p.m. The turbine receives steam at 425 lb. gage and 500° F. and exhausts to a feed heater at 10 lb. gage.



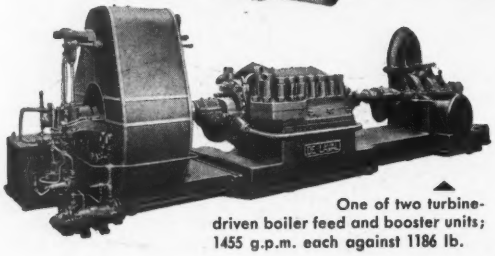
Six-stage boiler feed pump driven at 4000 r.p.m. through helical gear from 1800 r.p.m. motor; 125 g.p.m. of 218° F. water against 525 lb. per sq. in.



Turbine-driven six-stage boiler feed pump; capacity 850 g.p.m. of 220°F. water against 1600 lb. pressure at 3550 r.p.m. The turbine receives steam at 385 lb. gage and 650° F. and exhausts at 10 lb. gage.



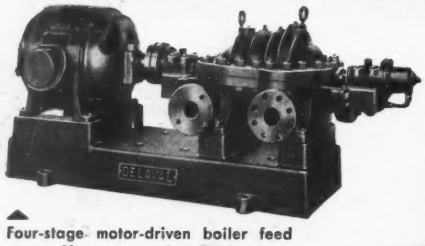
Motor-driven six-stage boiler feeder; 800 g.p.m. at 227° F. against 850 lb. per sq. in.



One of two turbine-driven boiler feed and booster units; 1455 g.p.m. each against 1186 lb.

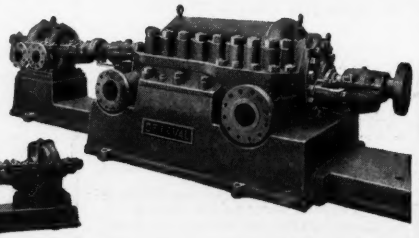
FEED PUMPS for Modern Boilers

DE LAVAL builds them

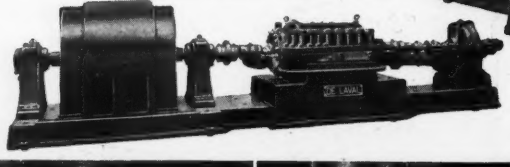


Four-stage motor-driven boiler feed pump; 28 g.p.m. against 375 lb., handling 210° F. water at 3500 r.p.m.

One of seven motor-driven and seven turbine-driven boiler feed and booster units; including capacities from 647 to 1320 g.p.m. of 300° F. water against pressures of 880 to 910 lb. at 1780 r.p.m. with 107 lb. pressure on the suction.



Motor-driven seven-stage pump with two-stage booster pump; 1200 g.p.m. against 1200 lb. at 1785 r.p.m.



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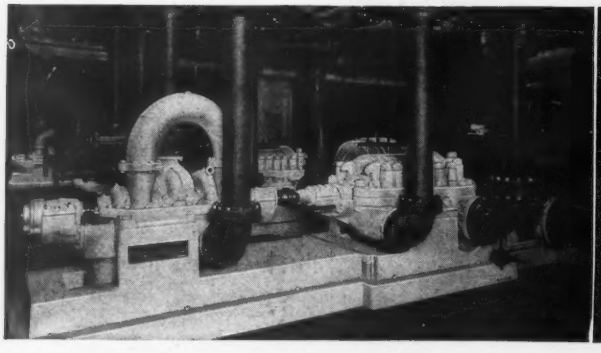
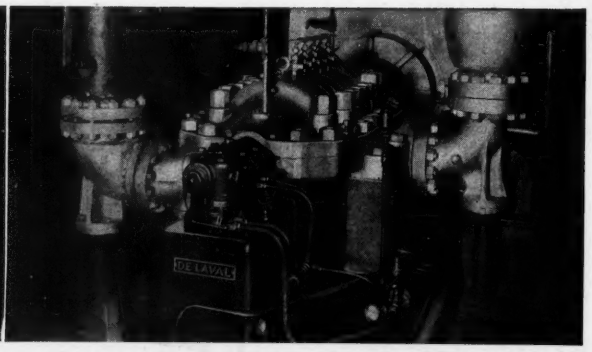


Two turbine-driven and one motor-driven combination boiler feed and primary pump unit; capacity 1455 g.p.m. each against 1186 lb. gage discharge pressure.



Motor-driven boiler feeder; 800 g.p.m. of 210° F. water against 1400 lb. This unit has had 40,000 hrs. of continuous service.

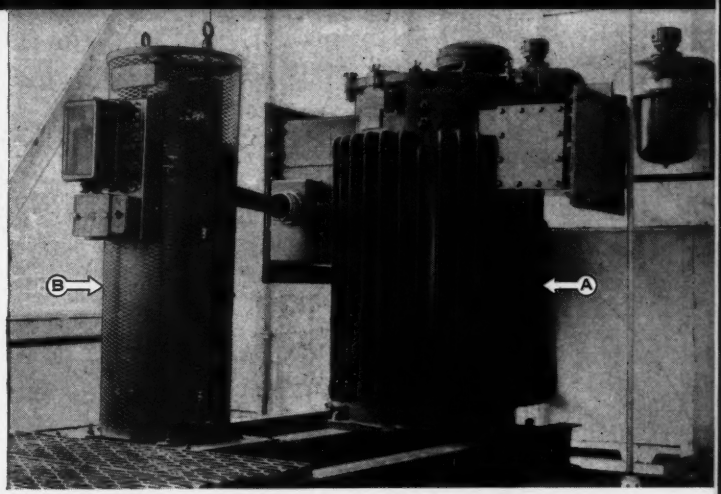
Ask for Catalog B-5 • De Laval Steam Turbine Co., Trenton, N. J.

Specify G-E Pyranol Transformers for All INDOOR Installations

You can install them right at the load center, without costly vaults, because Pyranol is noninflammable

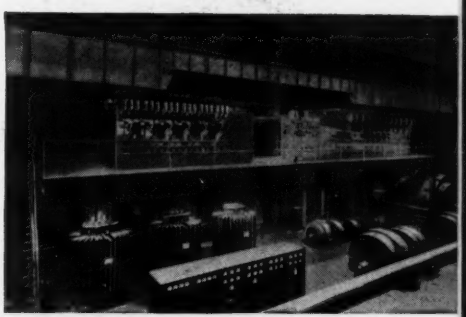
Use Them to Modernize Your Lighting Circuits

THINKING of improving the lighting in one of your buildings? Maybe you can save your present wiring by dividing the circuit into several sections and installing a G-E Pyranol transformer at the center of each section. Keep your present secondary wiring and run small 2300-volt primary copper to serve the transformers. Savings as high as 40 per cent have been made by this method. The technique is completely described in Bulletin GEA-3180. Ask your G-E representative for complete information on Pyranol transformers to meet your requirements, or write General Electric Co., Schenectady, N. Y.

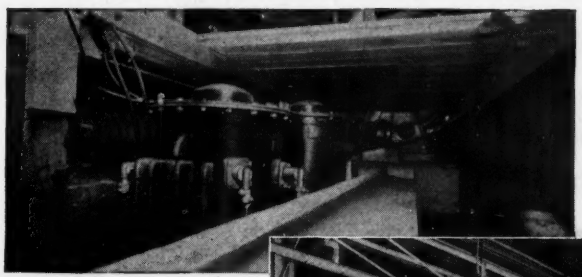


G-E Pyranol transformer (A) installed near the ceiling at the center of a modernized lighting circuit. G-E air-cooled regulator (B) provides precise voltage control for the lamps

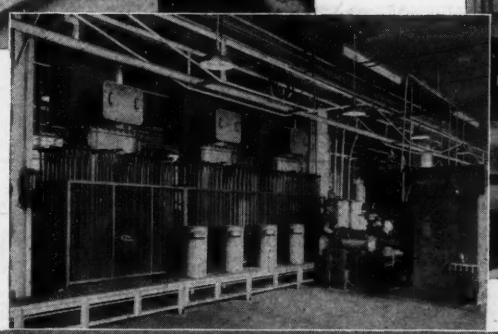
Use Them for Your Power Circuits and Enjoy the Benefits of Load-center Distribution



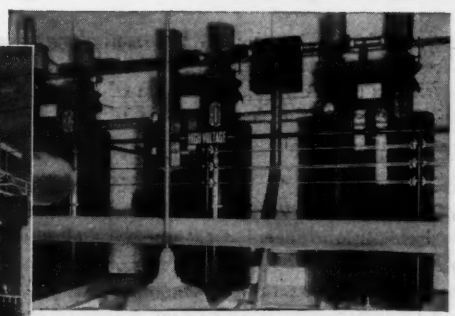
(Right) Load-center distribution at Jones & Laughlin Steel Corporation plant. Note locations of G-E Pyranol transformers right at the load, with no enclosing vaults



(Above) At the Boston Woven Hose & Rubber Company plant, marked savings were made because it was possible to install G-E Pyranol transformers in the nonproductive area right under the floor



(Right) G-E Pyranol transformers saved the day for us at our Pittsfield Works. Three 635-kva Pyranol transformers located right beside heavy-current-consuming resistance-welding machines on an upper floor cut costs and losses

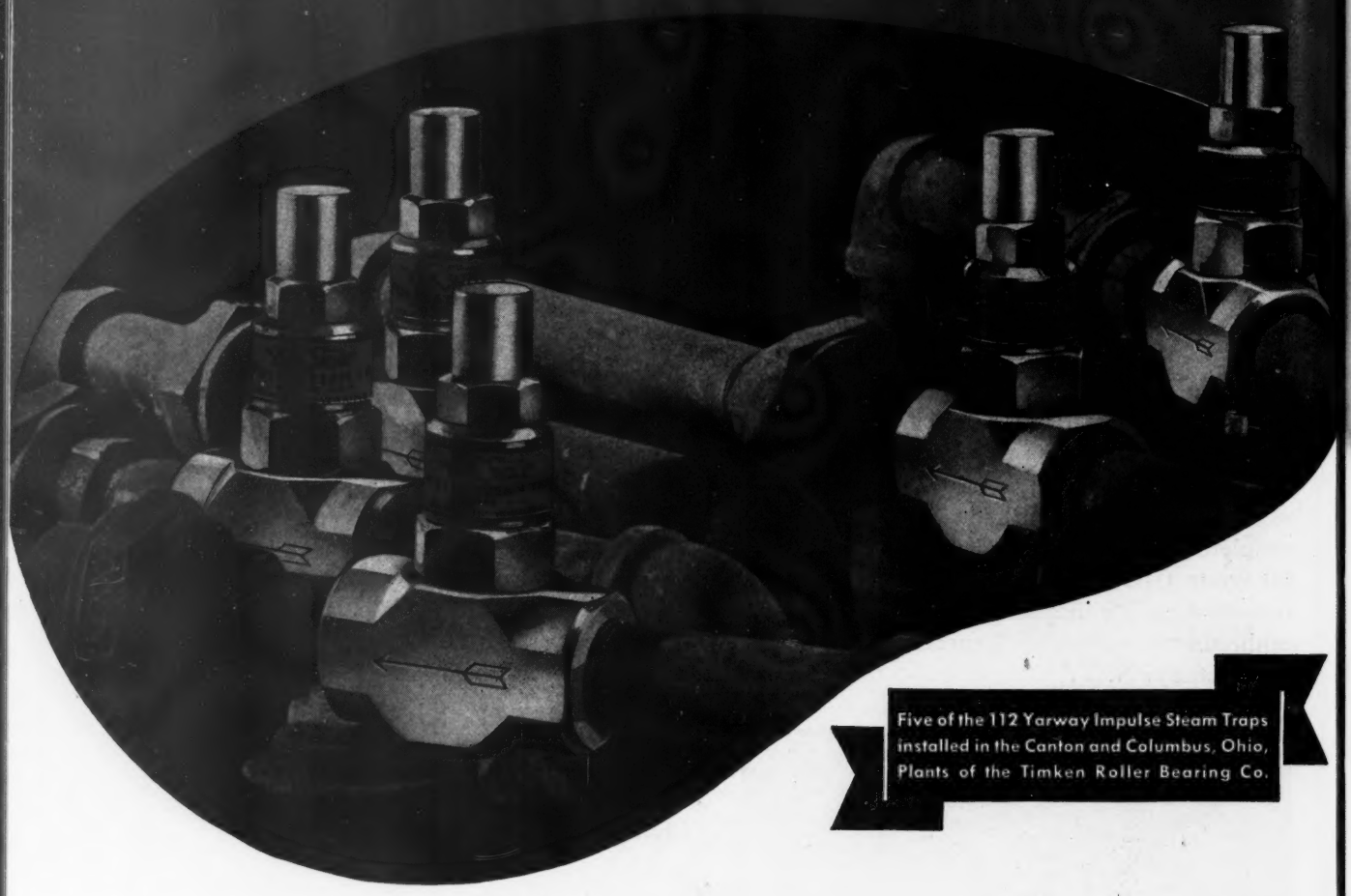


By mounting these Pyranol transformers on steel beams above the floor level, Acme Breweries, San Francisco, conserved floor space in its engine room. Savings in installed cost were realized because no vault was necessary

GENERAL ELECTRIC

300-72

TIMKEN *uses*
112 YARWAY IMPULSE TRAPS



Five of the 112 Yarway Impulse Steam Traps installed in the Canton and Columbus, Ohio, Plants of the Timken Roller Bearing Co.

THE world rolls on Timken Bearings. And Yarway Impulse Steam Traps are proud to have a hand in their manufacture —by providing more efficient operation of steam equipment in Timken's Canton and Columbus, Ohio, plants.

More than 50,000 Yarways have been installed

The list of Yarway-equipped plants reads like a "Who's Who" of American Industry. Yarway Trap performance talks. Quicker heating and greater sustained heating efficiency soon pay for the installation and continue to return worthwhile profits in plant operating economy. When you consider that their purchase price is usually no more than the cost of repairing an ordinary trap—why not get Yarway performance for your money?

Install a Yarway Impulse Trap or two and let them demonstrate what they can do for you in speeding production and saving fuel.

See how its small size saves space. How its light weight simplifies installation. How its unique design with only one moving part, and its rugged bar-stock construction, keep down maintenance expense. Then too, Yarway Traps are *suitable for wide range of pressures without change of valve or seat.*

A nearby Mill Supply Dealer handles Yarway Impulse Traps and will be glad to serve you. Or write for Catalog T-1734.

YARNALL-WARING COMPANY
114 Mermaid Ave. · Philadelphia, Pa.

YARWAY IMPULSE STEAM TRAP

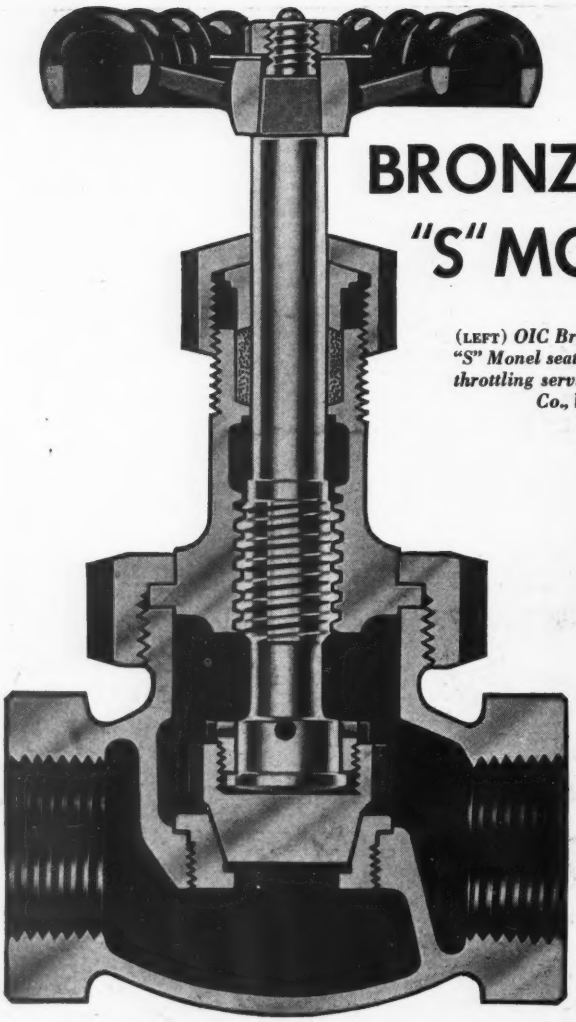
THE TOUGHER THEIR WORK THE BETTER THEY LIKE IT!

Controlling your pipe lines and guarding your media is their duty. They were made to handle a tough job. They are eager to prove their ability to give longer, trouble-free performance.

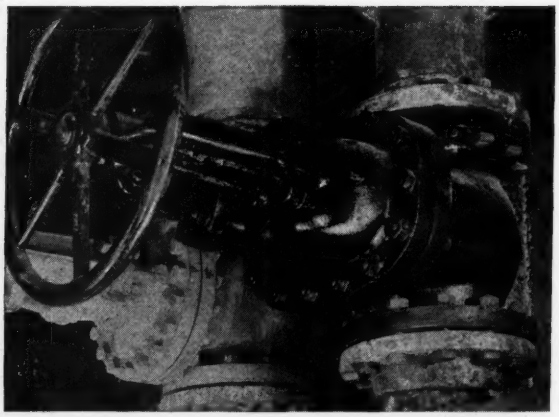
POWELL VALVES

THE WM. POWELL CO. CINCINNATI, OHIO

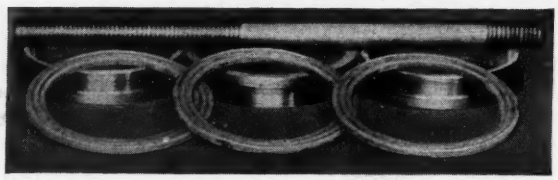
Why does this OIC BRONZE body Valve have "S" MONEL Seat and Disc?



(LEFT) *OIC Bronze Body globe valve with "S" Monel seat ring and plug type disc for throttling service. Made by Ohio Injector Co., Wadsworth, Ohio.*



Extra heavy 8" semi-steel gate valve also made by Ohio Injector Co. Trimmed with "S" Monel seat rings and disc rings and rolled Monel stems, shown below.



Designed for air, water or steam service, it needs parts that withstand high pressures and temperatures

Recently announced by Ohio Injector Co. of Wadsworth, Ohio is a new line of bronze body globe, angle and check valves. Two types are offered:

1. For full way service . . . in sizes ¼" to 3", with ball and cone seating.
2. For throttling service...in sizes ¼" to 2", with long plug discs.

For service conditions beyond the capabilities of bronze bodies larger semi-steel body valves are furnished.

Significant to any power engineer is the fact that *all three* types of these new valves are fitted with "S" Monel trim. The reasons? First: "S" Monel is non-galling, and highly resistant to erosion. Second: Up to 700° F. it retains undiminshed a hardness of 300-350 Brinell. Third: There are no adverse galvanic effects between valve bodies of bronze and trim of "S" Monel. Fourth: The "S" Monel seats and discs are machined after hardening by heat treatment, thereby providing a perfect seal when the valve is closed.

In addition to "S" Monel, there are other Nickel-base alloys which offer big advantages for power plant use. Exceptional resistance to heat, great strength and hardness, good spring properties, free machining, and other useful qualities characterize these metals. Write for further information. Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

• • •

"Monel" is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately two-thirds nickel and one-third copper.

"ACCURATE REGULATION OF STEAM TO ATOMIZING BURNERS *means* MONEY SAVING"

*Case No. 319

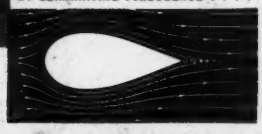
STRAIGHT LINE FLOW ELIMINATES TURBULENCE . . .

Gets HIGHEST VALVE CAPACITY

From inlet to outlet the fluid flows through this valve in a straight line — a streamline — almost as though there were a pipe running through the valve housing for the fluid to flow through. There is no detour around a dividing wall—the direction of flow is not changed at right angles because of a seat wall — also, the flow is not broken up by valve stems, springs, or other parts. The net result is NO TURBULENCE, hence MORE CAPACITY.

CASH STANDARD
Streamlined
TYPE 1000 PRESSURE
REDUCING VALVE
. . . GIVES YOU UNUSUAL EFFICIENCY PROVIDED BY THE STRAIGHT LINE FLOW OF AIR-STEAM-WATER-OIL AND OTHER LIQUIDS AND GASES THROUGH THE VALVE

SHOWING HOW THIS VALVE INCREASES PERFORMANCE RESULTS BY ELIMINATING TURBULENCE . . . .



. . . . AND HOW YOU ELIMINATE THIS TURBULENCE

Because of the streamlined flow, you are easily able to meet peak demand and yet hold the pressure constant at the same time. You get abundant flow when you need it most. No turbulence is set up and therefore operation is smoother—you have no pressure variation—you have constant, dependable action—you experience no spoilage results due to turbulence.

* "Regarding your Streamlined Valves, we use them for atomizing steam to our burners. Correct atomization means money saving. We need the lowest possible friction loss (pressure drop) through the valve that is possible. We need highest capacity possible on low pressure difference across the valve. We need constant delivery pressure from the valve regardless of changes in demand on the valve. Your Streamlined Valves give us these qualities better than any other make we have used. And it may interest you to know that we have found that we can count on your Capacity Charts too."

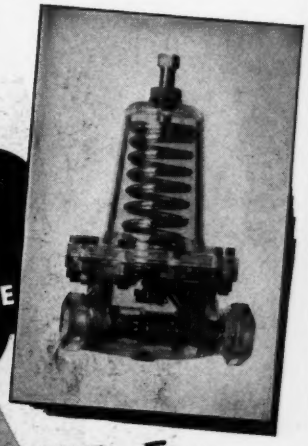
Statements from Streamlined (Type 1000) Valve users have come to us from all parts of the country—these verify the fact that this modern Streamlined Valve has no complicated parts to get out of order—no small ports or passages to clog up—nothing to keep it from working dependably—that you are easily able to meet peak demand and yet hold the pressure constant at the same time—that you really get high capacity flow when you need it most.

For example Case No. 305 says: "We are getting a better and more uniform product because our processing equipment is functioning better than ever before due to the even control the '1000' Valve is giving us. We also like the large capacity it is giving us."

Case No. 318 says: "Yes Sir! It's easy to say nice things about your Streamlined Valves. We like them very much. They have a whale of a lot of capacity. They control the reduced pressure within exceptionally close limits. They require NO maintenance—and I do mean 'NO!'."

The high pressure entirely confined to the small inlet chamber (cross hatched section) makes this valve good for initial pressures up to 3,000 lbs. The valve is furnished in sizes from ¼" x ¼" up to 2" x 2½" inclusive. For delivery pressures below atmosphere, a special diaphragm spring arrangement is used

A *Winner* WINS FIRST PRIZE



PHOTOGRAPH SENT *Free*

Recently we had a Streamlined Valve made of crystal clear plastic (pictured above) as a display piece for our plant.

The fabricator made a duplicate for himself and entered it in MODERN PLASTIC Magazine's Annual Contest.

First prize in the Industrial Parts, Moulded Group was awarded the plastic Streamlined Valve by MODERN PLASTIC Magazine.

We had a few photographic prints made of the Crystal Clear Streamlined Valve on display in our plant. Each of our representatives was given one. These men have found that the picture proved interesting to people they called upon because the entire simple and efficient construction of the Streamlined 1000 Valve is seen.

You may find it interesting to have one of these photos so that you can see the construction that enables straight line flow—so you can see construction that eliminates complicated parts—and that insures, as users say, "lots of capacity and exceptionally close pressure control."

A photograph will be sent you upon request.

SEND FOR BULLETIN 1000

30-DAY TRIAL *Free* OFFER

Write for details on this special offer made to give you an opportunity to find new ways to save money

A. W. CASH COMPANY

DECATUR, ILLINOIS

CASH STANDARD CONTROLS . . VALVES

TUBE-TURNS*

A BIG FACTOR for BETTER PIPING!

The hardest service in any piping system occurs at the fittings. That's where corrosion and erosion get in their worst licks. And that's where you need what Tube-Turns have . . . full wall-thickness at all points—smooth, uniform radius of curvature from face to face—tough, close-grained metal structure. . . . Tube-Turns match the pipe in O. D. and I. D. —make it easier to get sound, full-strength welds. They cost no more than other seamless fittings for pipe welding. Get the whole story. Write for Catalog No. 107. Tube-Turns, *Incorporated*, Louisville, Kentucky.

*The word "Tube-Turn" is NOT a necessary general trade name for welding fittings. It is the registered trade-mark for the products made by Tube-Turns, Incorporated, under their patents.

READING-PRATT & CADY VALVES that help you meet today's drive for lower costs . . .

For 350 lb. service—superheated steam to 550°F.—consider the FIG. 431-P at the right. Its stout body and stem have greater resistance to corrosion. Full plug type disc and seat are made of a new R-P & C alloy so hard that they are practically scar proof.

For 1500 lb. service, temperatures to 950°F. consider FIG. 15031 at the lower right—the completely engineered Cast Steel Valve—toggle operated and motor driven.

Just two examples to indicate that we can be helpful when you are considering valves. Your request will be answered promptly.

FIG. 15031. Carbon Molybdenum Cast Steel Globe Valve with Stellite surfaced disc and welded-in seat ring.

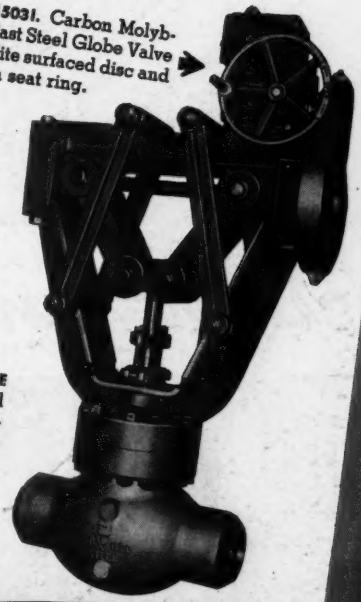


FIG. 103. 150 lb. Bronze Gate Valve. Rugged. Adds much to length of valve life in this service.

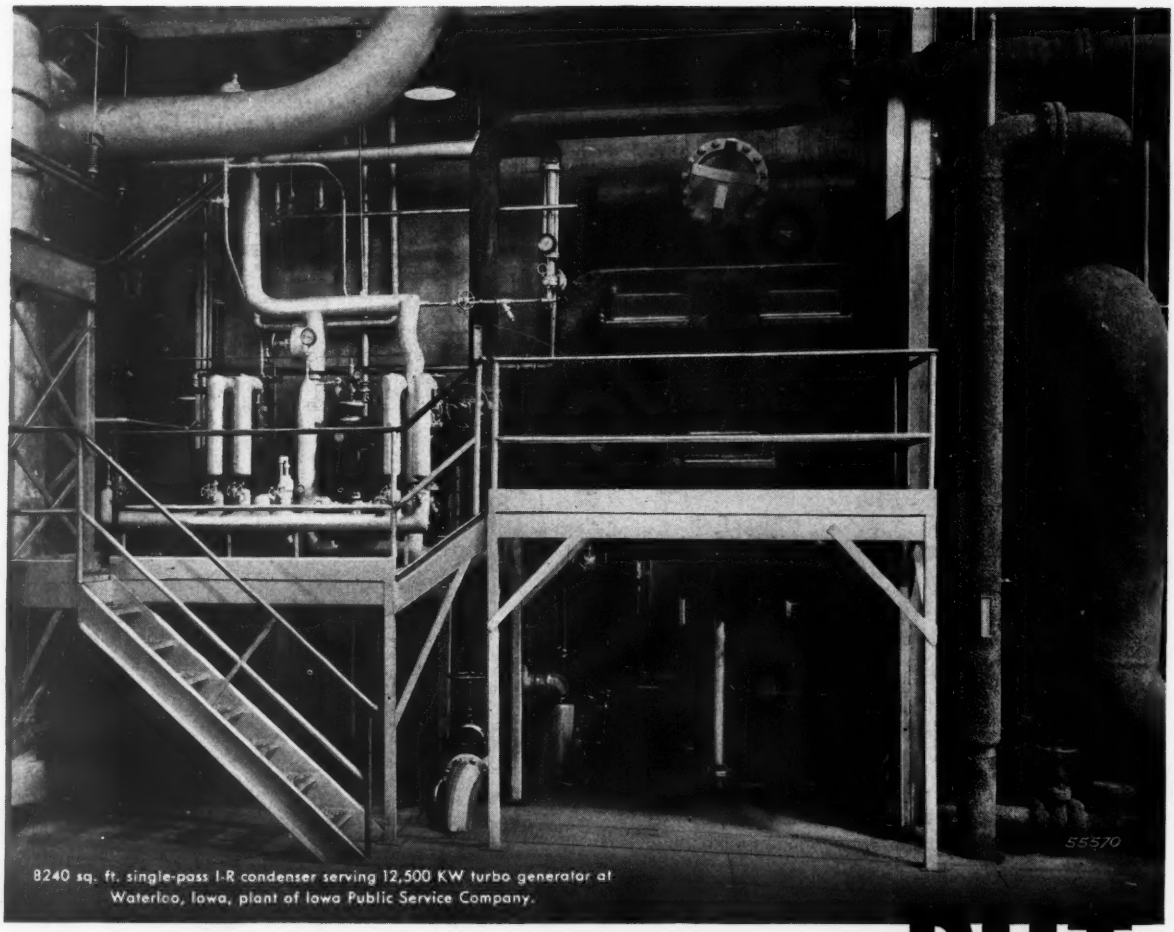
BAR STOCK VALVE Globe, Angle and Thru-port types. Precision made on automatic machines.

READING-PRATT & CADY

READING-PRATT & CADY DIVISION · BRIDGEPORT · CONNECTICUT

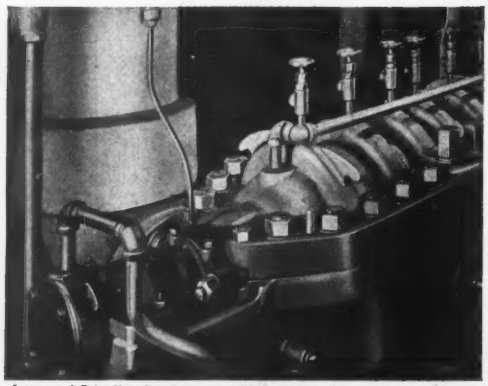
AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION • AMERICAN CABLE DIVISION • ANDREW C. CAMPBELL DIVISION • FORD CHAIN BLOCK DIVISION • HAZARD WIRE ROPE DIVISION • HIGHLAND IRON AND STEEL DIVISION • MANLEY MANUFACTURING DIVISION • OWEN SILENT SPRING COMPANY, INC. • PAGE STEEL AND WIRE DIVISION • READING-PRATT & CADY DIVISION • READING STEEL CASTING DIVISION • WRIGHT MANUFACTURING DIVISION • IN CANADA: DOMINION CHAIN COMPANY, LTD. • IN ENGLAND: BRITISH WIRE PRODUCTS, LTD. • THE PARSONS CHAIN COMPANY, LTD. • *In Business for Your Safety*



8240 sq. ft. single-pass I-R condenser serving 12,500 KW turbo generator at Waterloo, Iowa, plant of Iowa Public Service Company.

Nothing unusual here—BUT



6-stage I-R boiler feed pump at Waterloo, Iowa, plant of Iowa Public Service Company.

Unusual and spectacular installations are interesting, but dependability, efficiency and low maintenance expenses are the factors which assure real savings in most plants.

The illustration above shows an Ingersoll-Rand 8240 sq. ft., single-pass condenser together with twin element steam jet ejector serving a 12,500 KW turbine generator unit at the Iowa Public Service Company's plant in Waterloo, Iowa. This plant was designed by Stevens and Wood, Inc.

Hundreds of Ingersoll-Rand surface condensers of all sizes are efficiently and dependably serving public utility, private and marine power plants everywhere.

Ingersoll-Rand
11 BROADWAY, NEW YORK, N. Y.

818-4

Atlanta, Birmingham, Boston, Buffalo, Butte, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Duluth, El Paso, Hartford, Houston, Kansas City, Knoxville, Los Angeles, Newark, New York, Philadelphia, Picher, Pittsburgh, Pottsville, Salt Lake City, San Francisco, Scranton, Seattle, St. Louis, Tulsa, Washington

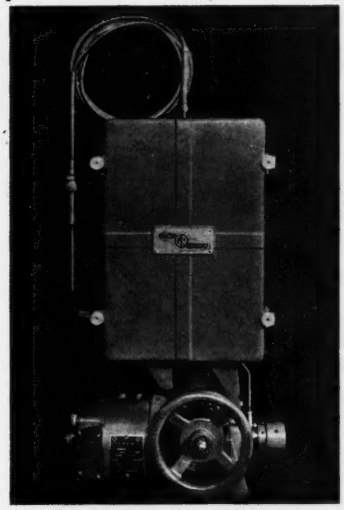
Positive Controls

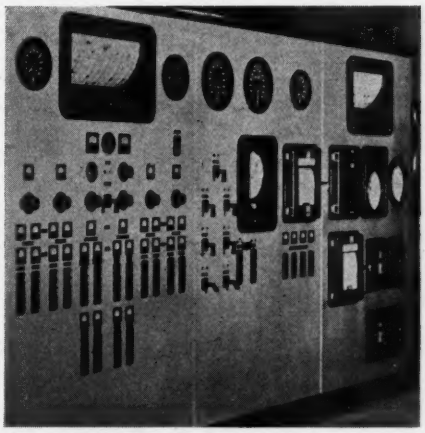
ABSOLUTE STABILITY

Combustion control governed by the "G-R" Electric Master System gives basic proportional flow of fuel and air with straight line master loading voltage and heat input quantities, providing inherent stability of the highest order.

ELECTRIC

Standard "G-R" Electric Regulator, fully stabilized without interrupters or time switches, employs the new principle of inertia stabilizer. Furnished for all applications where accurate control of pressure, temperature or volume is required. Three methods of operation are provided—automatic; remote manual push button; and direct manual control by hand wheel operation. Available in four sizes of gear cases delivering from 25 to 1200 ft. lb. torque. Motors either A. C. or D. C., any voltage, phase or frequency.





"G-R" centralized combustion control master panel including:—Automatic-to-manual master transfer switch, load meters, fuel-air ratio indicators and push button control of each actuator. Small meters show the operator relative position of each regulator and actuator.

Individually Engineered

COMBUSTION CONTROL

PRESSURE REDUCTION

DESUPERHEAT CONTROL

SUPERHEATED STEAM TEMPERATURE REGULATION

GENERAL REGULATOR CORPORATION

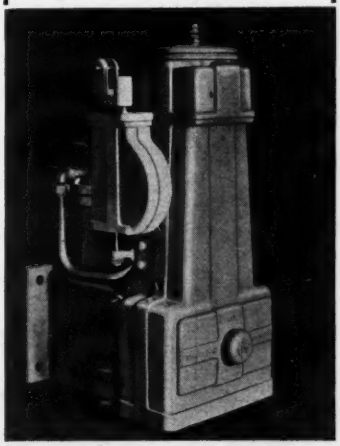
165 Broadway, New York

HYDRAULIC

Standard "G-R" Hydraulic Regulator is universally adaptable to the control of combustion processes, boiler feed water level, pumping systems, pressure reducing, desuperheating, gas mixing, turbine control and other problems of pressure, speed, volume, temperature and liquid level regulation.

With the exception of primary control elements, each regulator in a system is alike and interchangeable.

The use of the velocity jet type, frictionless stabilizer results in a high order of stability, sensitivity and speed of response.



General Regulators

Sales Representatives

FOSTER WHEELER CORPORATION

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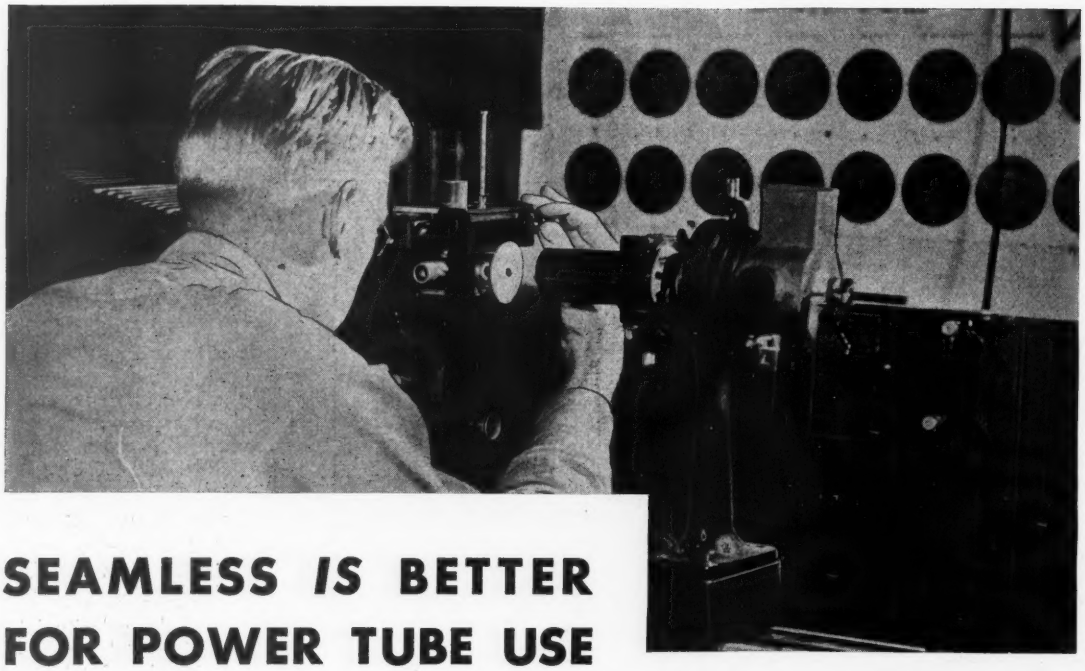
LAB ANALYSES TELL THE STORY...



SEAMLESS *IS* BETTER FOR POWER TUBE USE

And what is proved in the laboratory, *Pittsburgh* Seamless confirms on the job . . . that tubing produced by the *seamless piercing* process has greater strength, longer life, higher safety factors, and uniform dependability. Three incontravertible facts make this so: (1) Only *good* steel can withstand the piercing; (2) the process itself further refines the steel; (3) the resultant homogeneous wall structure eliminates zones of potential weakness. Add *Pittsburgh's* 36 years of experience manufacturing *seamless,* their *single* responsibility from "ore to final inspection," and you have abundant reasons for relying on *Pittsburgh* Seamless Tubing for your power uses.

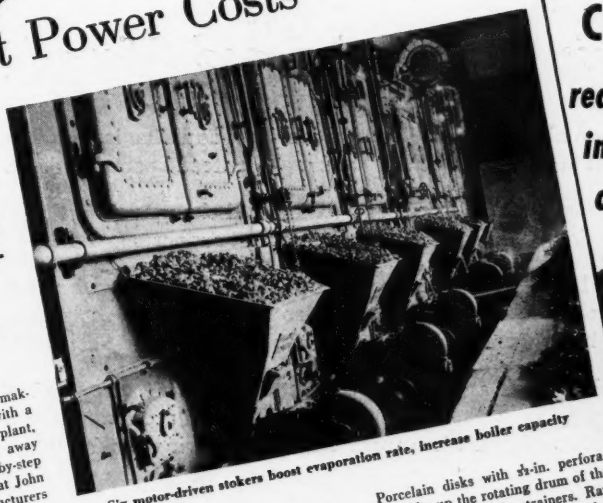
PITTSBURGH STEEL COMPANY
1654 GRANT BUILDING PITTSBURGH, PA.

. THERE IS NOTHING EQUAL TO SEAMLESS

Step-by-Step Improvements Cut Power Costs

John R Evans & Co finds that continuous modernization slashed boiler and condenser maintenance by half, boosted boiler evaporation rate

By ARTHUR B SULLIVAN
Plant Engineer



Six motor-driven stokers boost evaporation rate, increase boiler capacity

FOR EVERY POWER engineer making big dents in power cost with a new or completely rebuilt power plant, there are many more nibbling away at operating costs through step-by-step improvements. That's the story at John R Evans & Co, leather manufacturers of Camden, N. J., where continuous modernization cut boiler and condenser maintenance in half and, by boosting boiler evaporation rate, automatically ... down steam and electric ... sists of eight ... supplying ... tory ... lighting current during shutdowns.

So much for the plant—what about the improvements? First point of attack was the plant water supply, which was a continuous source of trouble. All water, including boiler-feed makeup, came from the Delaware River. In spite ... strainers, dirt and impurities in the ... used condenser- and boiler-tube ... strainers themselves had ... and cleaned at fre- ... tion of two ... each ...

Porcelain disks with ⅛-in. perforations make up the rotating drum of the new H A Brassert Co strainers. Raw water flows through these disks during half a revolution of the drum; during the other half, a small quantity of clean water backwashes the disks, thus presenting a clean surface when they again move into the straining cycle. About 5% of the water strained is needed to keep the drum clean. Freedom from upkeep for two years has marked experience with these units and no manual cleaning has been required.

Improvement in water condition shows up in condensers through which

(557) 99

With two turbine-driven stokers, operators can make steam for heating when plant is shut down, without needing to generate electricity

... strained ... water circulates before passing to th... ...t-water tank. Original- ly, operators ha... ... open and clean the condensers once ... week Now con- densers go six mont... ...without cleaning.

Boiler Fe...

In the same way boiler m... ...nance was cut, but here some of the ... just go to other changes in the fe... ...ater and boiler circuits. One of these ... a addition of a clarifying arrange ... ...t designed to take the place of blow ... ...n and treatment other than strain ... In operation, the Clarifier Corp ... ...n continuously draws off small ... ...ities of surface water from each ... passes it through an enclosed ... ...nd returns it to the boiler.

for cleaning once a month with all the regularity of a good calendar, they can now go nearly a year before tubes need attention. Instead of spending a week or more on hard-scale removal, operators can remove present coating of mud in three days.

Over a ...

...during on all eight ... have ... On the first six boilers, Detroit single-retort units, motor-driven, handle the firing job but on the last two boilers, turbine-driven stokers, of similar make and type, fit into the plant heat balance. With these units, operators can supply ... steam for winter heating during week- ... when the factory is shutdown, with ...

John R. Evans & Co. Camden, N. J.

reduce steam costs— increase capacity of eight boilers with Detroit Unit Stokers

DETROIT STOKERS . .

in modernization programs

Hundreds of plants have found Detroit Stokers productive of important gains in efficiency. They will fit the program, whether modernization is conducted step by step, or all changes made at one time.

Detroit Stokers are built in many types and sizes for all power and heating requirements.

Write for Bulletin 624—reprint of the article in September, 1939 issue of POWER.

DETROIT STOKER COMPANY

Fifth Floor, General Motors Building, Detroit, Mich. • Works at Monroe, Mich.
District Offices in Principal Cities • Built in Canada at London, Ontario

Thermix Stack

Reduces Installation and Operating Costs

In a single simplified unit, the Thermix combines a mechanical draft fan, a stack and breeching. Thus, you get "unit responsibility" and a guaranteed operating draft.

This original fan-stack reduces bends, turns and changes of section to a minimum. It saves money in the drafting room, in decreased structural supports and steel and in power consumed.

The stack can be installed at a level with the top of boiler, saving material from the ground to boiler level and eliminating breeching. It also saves building costs because it is compact and, although of extra heavy construction, lighter than a cylindrical stack and induced draft fan.

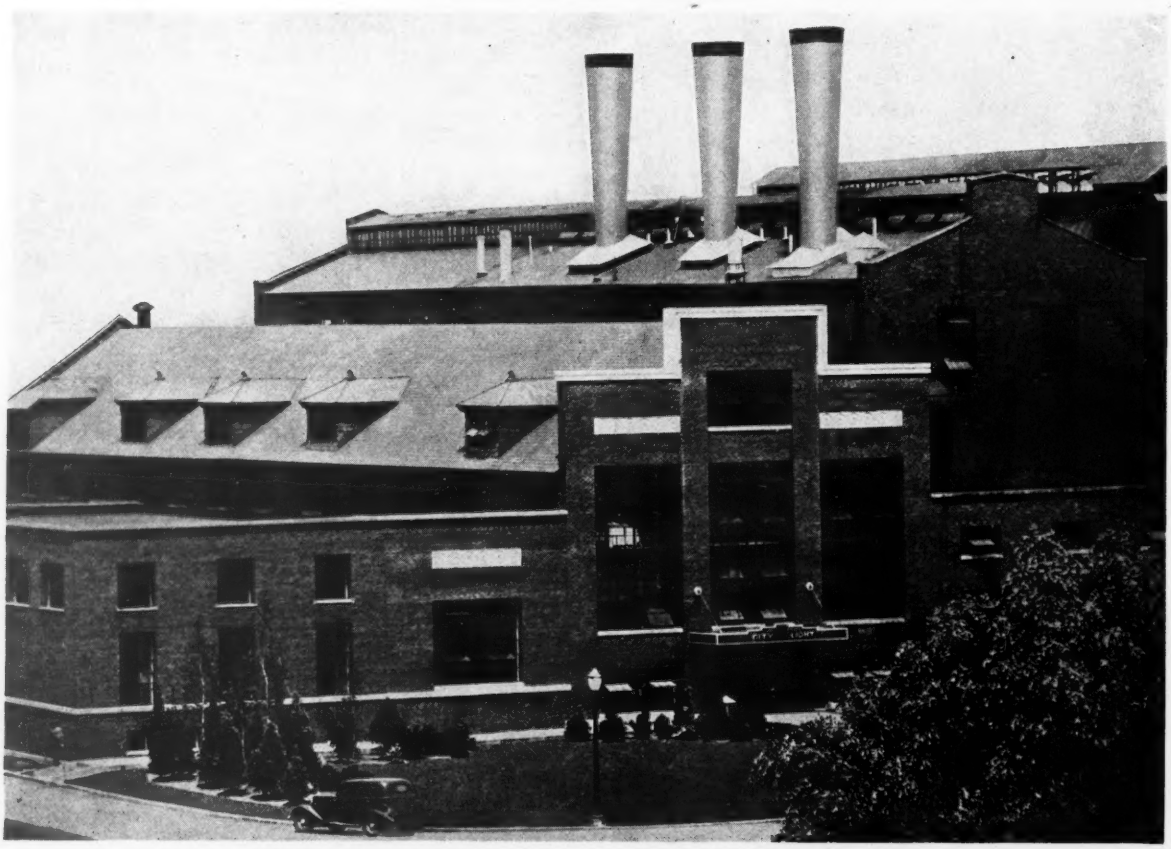
The fan wheel operates at low tip speed but a high shaft speed and with lower cost motors. Fan blades can be supplied with "Thermix-blades"—which are removable wearing surfaces which can be inexpensively replaced when worn without removing the fan wheel from casing or rebalancing fan.

You'll find many other money-saving achievements explained in our catalog. Write for a copy.

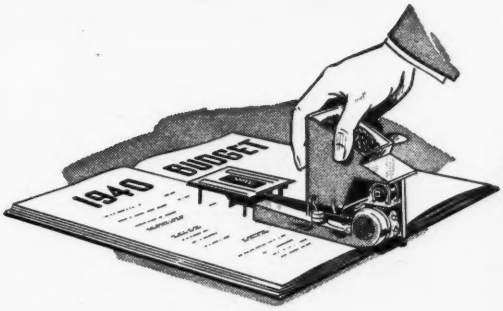
Prat-Daniel Corporation

86 SOUTH WATER ST., PORT CHESTER, N. Y.

Representatives in Important Cities



Put IRON FIREMAN *into your 1940 budget*



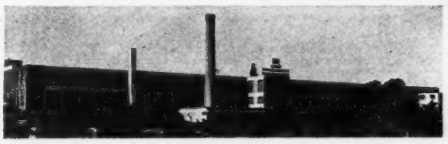
What other investment can earn so much for you? Decide now that in 1940 you will *modernize, Iron Fireman-ize* your boiler plant. Iron Fireman will step up operating efficiency to a new high, and at the same time earn an exceptional return on the investment.

For instance, *Bowser Pump,* Fort Wayne, Ind., is earning a 76% return on its Iron Fireman investment. *Massengill Laboratories,* Bristol, Tenn.-Va., is receiving a 39% annual return; and its 12 Iron Fireman stokers have given 50 years' combined service at a total service cost of only $29.20. *Patterson Mills,* Roanoke Rapids, N. C., is collecting annual cash savings amounting to 87% of its three Iron Fireman Powerams, with steam costs cut from 35 cents to 20.8 cents.

Let us make an Iron Fireman Engineering Survey of your plant. We cannot promise *you* such tremendous savings—unless your situation offers similar opportunities for improvement. But if you will authorize us to make a survey of your steam costs at our own expense, we will give you a conservative report showing what Iron Fireman *can* do. We will work in cooperation with your own engineer, consulting engineer, or fireman. The survey report can be incorporated, if you wish, in your 1940 budget recommendations. Send the coupon, and we will do the rest.

"Iron Fireman cut our fuel budget 20%"

. . . reports John K. Voehringer, Jr., president, Mock, Judson, Voehringer Co.



Greensboro, N. C., mill of Mock, Judson, Voehringer: one of the largest and finest full-fashioned hosiery mills in the South; where three Iron Fireman stokers have operated for 10 years.

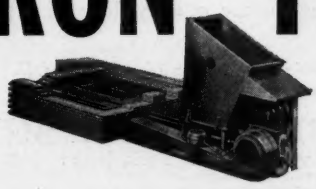
New hosiery mill in Siler City, N. C., where a new Iron Fireman *Poweram* underfeed stoker is providing low-cost steam.

In 1929 the Mock, Judson, Voehringer Company installed three heavy-duty Iron Fireman stokers in its boiler room. These stokers are now entering their second decade of operation—piling up fuel savings compared with hand-firing, at the rate of 20% a year. Maintenance cost on all three stokers combined, over the entire 10 years, has been only $350, reports President Voehringer. He adds that with Iron Fireman firing, "we maintain uniform pressure *regardless* of steam demands for processing work and heating. Boiler room expense has been reduced to a minimum through the use of lower-cost sizes of coal, reduction in tonnage burned, and reduction in labor required."

When the affiliated concern, the Siler City Hosiery Co., erected a new mill recently, a new Iron Fireman *Poweram* was promptly installed . . . making the fourth Iron Fireman heavy-duty stoker operated by Mr. Voehringer.

IRON FIREMAN

Automatic Coal Stokers



IRON FIREMAN MANUFACTURING CO., Portland, Ore.; Cleveland; Toronto.

Mail to 3219 West 106th Street, Cleveland, Ohio.

☐ See us about making an Iron Fireman Engineering Survey of our steam costs.

Send ☐ Industrial Power Catalog
☐ Commercial Heating Catalog.

Name_____

Address_____

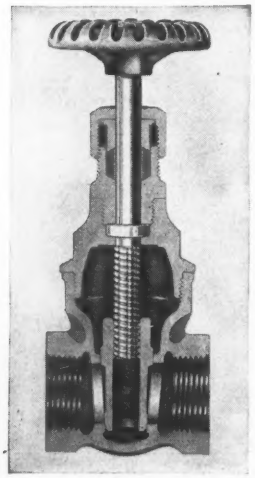
One look at the heavy, husky body of these new Fairbanks Bronze Gate Valves, with reinforced ribs at the sides and bottom, and you will say "There's quality!"

Quality is reflected in every one of the advanced, modern features that make these Fairbanks Valves such outstanding value.

All that Fairbanks has learned in more than 50 years of valve manufacturing has been incorporated in these

Fairbanks
New Bronze Gate Valves

Larger, stronger pipe end Hexes . . . large bonnet Hex which projects over the bonnet threads . . . big clearance between end of threads and diaphragm . . . greater length of threads . . . reversible wedges . . . rib guides in body, and heavy internal ribbing in wedge, are but a few of the outstanding features. Similar evidences of quality are apparent throughout.

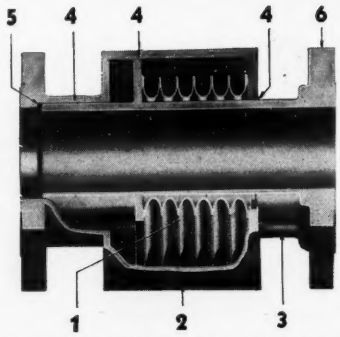


They're made in non-rising stem, with solid tapered wedge; rising stem with slip-on solid or split wedge. Distributors everywhere stock these valves.

Write for our new booklet.

The FAIRBANKS CO.
399 Lafayette St. New York, N. Y.
Boston Pittsburgh
Distributors in Principal Cities
Factories:
Binghamton, N. Y. Rome, Ga.

ADSCO U-RING JOINT
With PACKLESS FLEXIBLE STEEL ELEMENT



REQUIRES NO MAINTENANCE

The only packless expansion joint where the expansion element is under compression when in operation and under minimum flexing strain when in service.

As illustrated above (1) is Expansion Element of corrosion resistant steel welded U-Rings forming a permanent seal between stationary body and movable sleeve (2) Steel Body (3) Movable Sleeve with full, unrestricted opening through joint (4) Three-point guiding for the sleeve throughout entire traverse (5) Limit Stop (6) Flanged ends for pressures to 300 lbs. or with beveled ends for welding.. Available with or without anchor base.

Write for new Bulletin No. 35-50A.

AMERICAN DISTRICT STEAM COMPANY
NORTH TONAWANDA, N.Y.
IN BUSINESS OVER SIXTY YEARS

Enco Burners
for all grades of Oil and Gas

Efficient combustion; increased boiler capacity; wide flexibility in application; adaptability to all grades of fuels; and simplicity in operation, are secured by the installation of ENCO BURNERS.

Furnished in standard steam and mechanical atomizing types, either with or without air registers, and for natural or forced draft, or a combination of the two.

The Enco interchangeable oil burner is made for mechanical, steam or air atomization in capacities up to 100,000 pounds of steam per hour.

An ENCO Oil Atomizer used with any Pulverized Coal Burner, provides a dual fuel unit, which insures against the loss of steam when coal supply to burner fails for any reason.

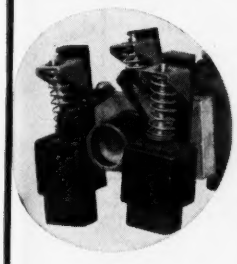
We have made many installations and would be glad to cooperate with those looking for better operation and assurance against loss of steam output.

Write for Bulletin OB-37 describing ENCO OIL BURNING EQUIPMENT.

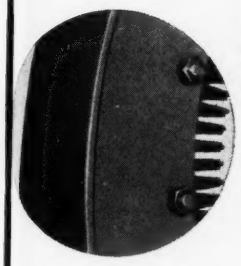
THE ENGINEER COMPANY
17 Battery Place, New York, N. Y.

15 Years and Not One Cent for Repairs on Two G-E Synchronous Motors

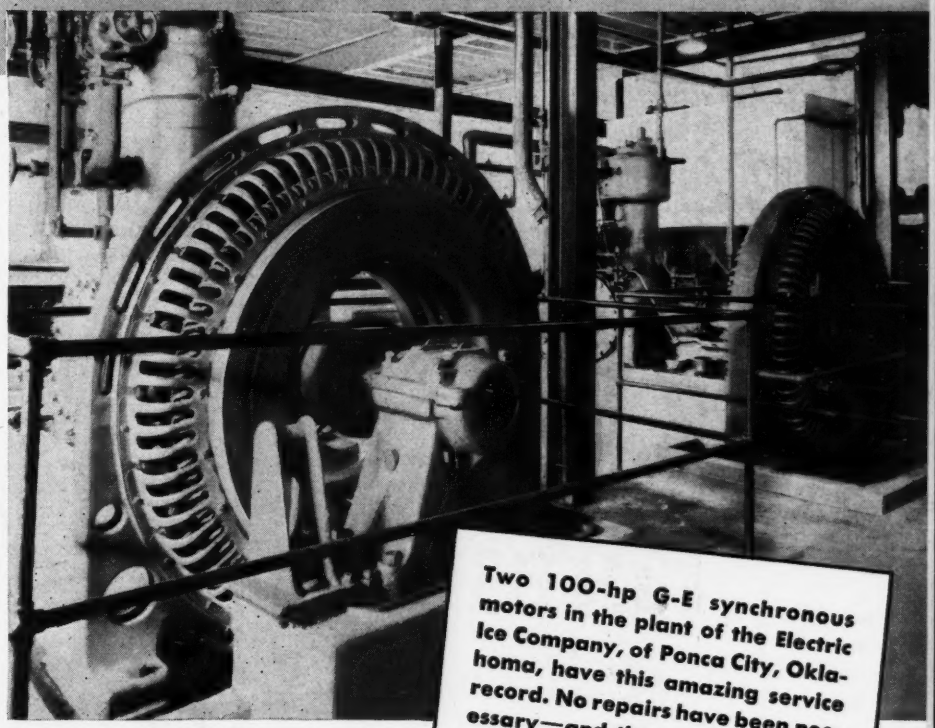
Exceptionally long life is made possible by the great mechanical strength of the stator-coil insulation. The use of insulating varnishes and compounds developed in the G-E Research Laboratory, in addition to precisely controlled manufacturing processes, results in added years of service



One-piece, die-cast, box-type, alloy brush holders with adjustable, radial-spring pressure give uniform brush contact on the collector rings at all times. A simple adjustment of the spring support maintains uniform pressure as the brushes wear



This deep, sturdy, channel-shaped steel frame, consisting of a heavy wrapper plate firmly secured by continuous welds to two deep side plates, assures rigidity and the maintenance of a uniform air gap under all stresses and shocks of normal operation



Two General Electric synchronous motors direct-connected to compressors in the plant of the Electric Ice Company, of Ponca City, Oklahoma

Two 100-hp G-E synchronous motors in the plant of the Electric Ice Company, of Ponca City, Oklahoma, have this amazing service record. No repairs have been necessary—and the original brushes were still in use after 15 years.

THESE two General Electric synchronous motors have operated for 15 years without costing one cent for repairs. This is a demonstration of the fact that G-E synchronous motors are built to last. Long life is considered in every step of motor design—extra years of dependable service are literally built into G-E synchronous motors.

In addition to furnishing a reliable, efficient drive for the Electric Ice Company's compressors, these motors increase the total plant power-factor, with a consequent reduction of the monthly power bill. Not only has the power-factor been improved—with resultant savings—but, in addition, better operation of all other electric apparatus is obtained through the improved voltage regulation of the electric system.

Synchronous motors are the most efficient and reliable drives for many constant-speed applications, such as certain types of compressors and pumps. General Electric can furnish synchronous motors with a wide variety of electrical and mechanical modifications—and with control to match—which will meet your particular conditions of voltage and power-factor. For further information, get in touch with our nearest representative, or write General Electric, Schenectady, N. Y.

General Electric Company
Dept. 6C-201, Schenectady, N. Y.

Please send me a copy of your new 52-page booklet (GEA-1191B) on synchronous motors.

Name.....

Company.....

Address.....

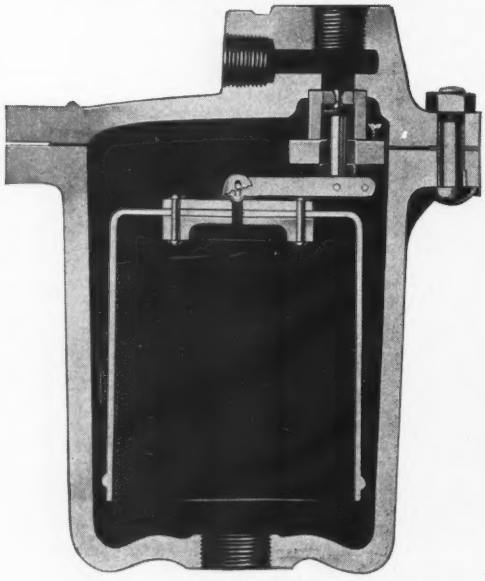
040-69

GENERAL ELECTRIC

PIPEWRENCH PETE SAYS:

Here's Why STRONG Inverted Bucket Traps DON'T BALANCE!

Exclusive "Trigger" Vent Gives Sharp, Intermittent Action



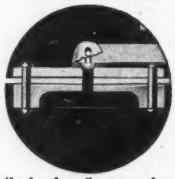
Saves on Production, Steam, Upkeep!

Now, STRONG gives you inverted bucket traps with an exclusive "trigger" action vent that ends balancing once and for all!

Full, intermittent operation, plus Anum-Metl seats and discs, plus wear-proof parts permit us to guarantee STRONG traps a full year against leakage or wear.

Write for your copy of catalog 63-PE12 today!

Here's The STRONG "Trigger" Vent!



While bucket floats, valve almost closes vent. As bucket fills and reaches point of discharge, it starts to sink, removing valve from vent. This allows large quantity of air to escape suddenly, and causes bucket to sink to the bottom. Assures full, intermittent action.

The Strong, Carlisle & Hammond Co.
1392 West Third St., Cleveland, O.

STRONG
STEAM SPECIALTIES

Water Will Flow Up or Down Tank Level Will Not Change

ALTITUDE GOVERNOR
Ask for Bulletin 2983

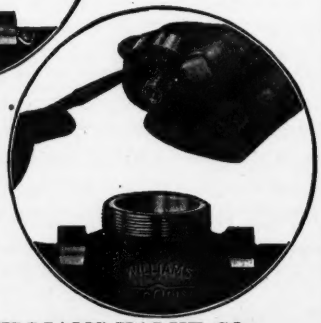
To keep inlet and outlet under balanced control, so that the water level in the tank does not vary, is the function of the C-F Altitude Governor. So long as tank pressure is less than pump pressure, flow will be upward. If tank pressure becomes greater than pump pressure, flow will be reversed and downward movement will relieve the excess. Full flow in either direction is unhindered and the desired level is maintained, with resulting economy as well as safety.

The **CHAPLIN-FULTON MFG. CO.**
28-40 PENN AVE. CF PITTSBURGH, PA.

Use **VULCODISC**

for trouble-free valve jobs

In renewing the disc, note how easily and quickly the Vulcodisc Jiffy Disc Holder slips off the stem head. Only the disc lock nut to remove and the old disc is off and replaced in a jiffy.

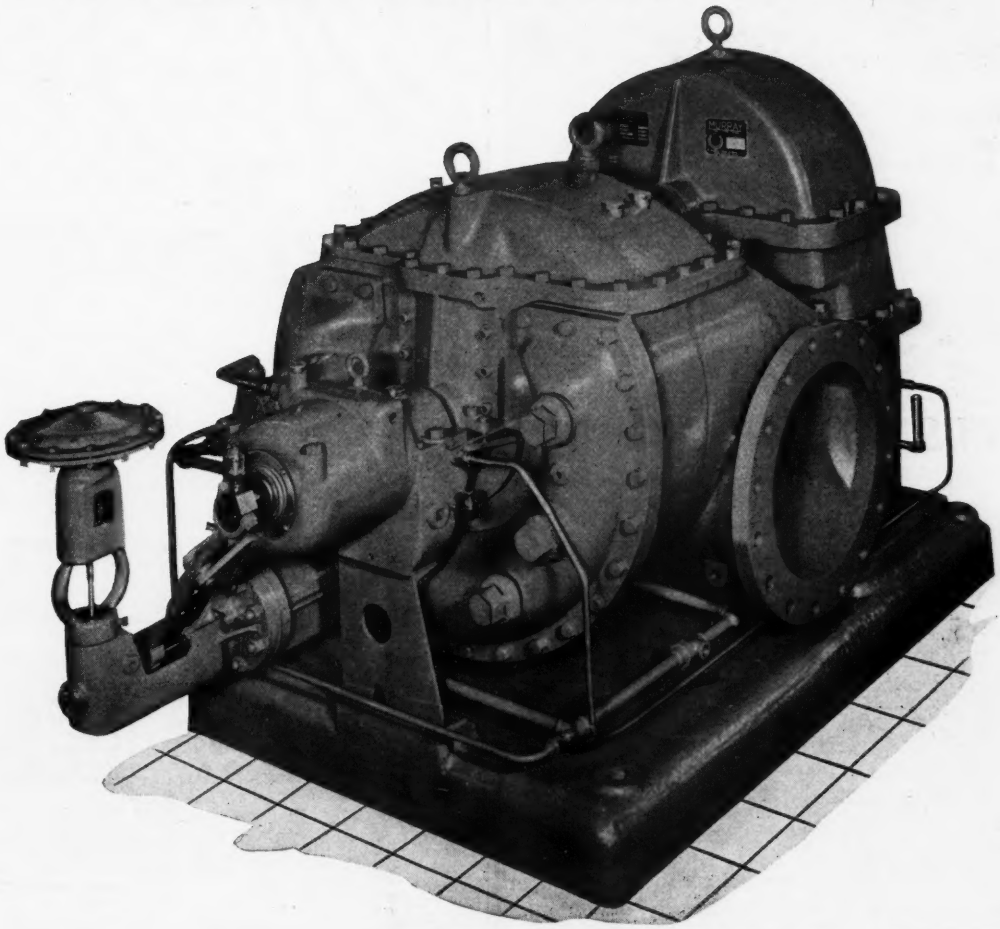


Dense without being brittle—tough, yet resilient, Vulcodisc will not swell, warp or soften—in fact its absorption is less than 1 per cent. . . That is why an old Vulcodisc comes out of the disc holder as easily as a new one goes in. No need for hammer and chisel to cut the disc out in pieces—distorting and disfiguring the holder.

Write for descriptive bulletin.

THE D. T. WILLIAMS VALVE CO.
Cincinnati, Ohio

MURRAY TYPE "UV" MULTI-STAGE TURBINES
with
INTEGRAL REDUCTION GEARS



225 HP, 5000/1200 RPM, 3-Stage Murray Type "UV" Integral Geared Unit with "built-in" Constant Pressure Governor for High Pressure Condensing Pumping Service.

MURRAY Type "UV" Multi-Stage Mechanical Drive Turbines

— plus —

MURRAY Integral Reduction Gears

— equal —

the correct answers to your mechanical drive problems demanding high efficiency with simple, rugged construction and minimum space requirements.

A complete line of sizes and types is available.

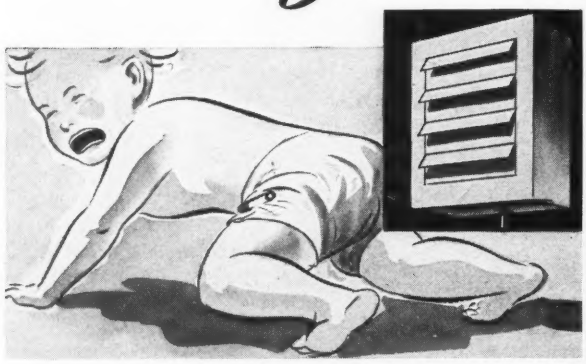
These modern MURRAY Steam Turbine Drives are daily delivering thousands of horsepower where reliability and economy are of utmost importance. The following are typical of many actual applications:

Reciprocating Compressors (thru "V" belts)
Centrifugal Pumps
Induced Draft Fans
Forced Draft Fans
Coal Pulverizers
Jordan Paper Machines

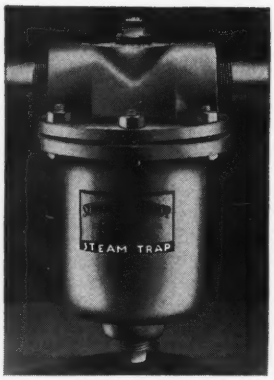
Our district representative, or our home office will furnish complete information promptly upon your request.

MURRAY IRON WORKS COMPANY, BURLINGTON, IOWA.

A Cold Bottom



Means it's time to change



● A unit heater with a cold bottom is a unit heater that needs a change of steam traps – a change to Anderson Super-Silvertop. The change is needed because the old trap is not removing air and condensate from the system. That is why the unit is cold—it isn't full of hot, dry steam.

Anderson Super-Silvertop steam traps keep a unit heater bone dry and free of entrained air at all times. Over fifty years of steam trap manufacturing experience back the design of this engineered steam trap. It has guided bucket, straight-in-line and built-in elbow piping, ease of inspection and extra long service life.

Examine your unit heaters—remember that a cold bottom means it's time to change —to Anderson Super-Silvertop.

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Super-Silvertop
STEAM TRAPS

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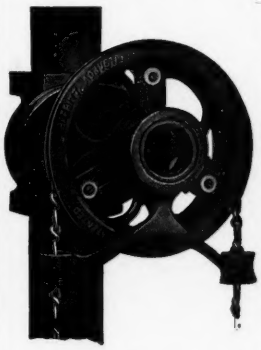

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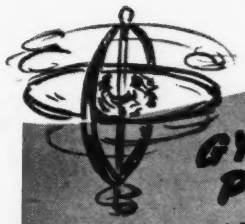

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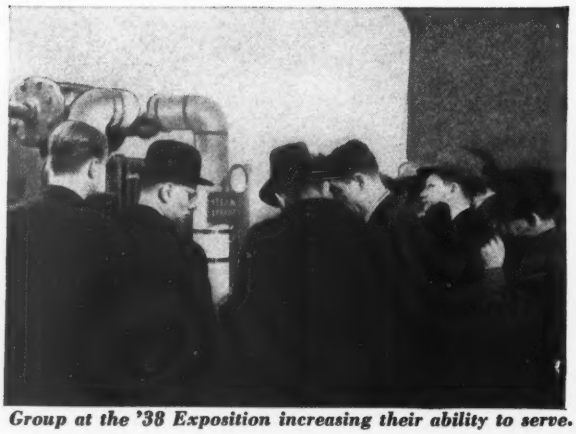

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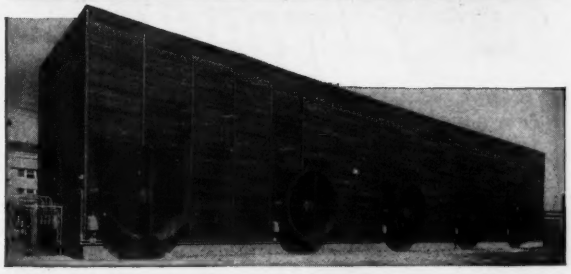

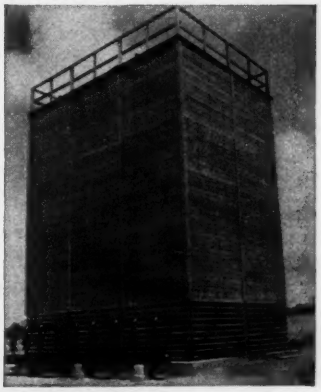

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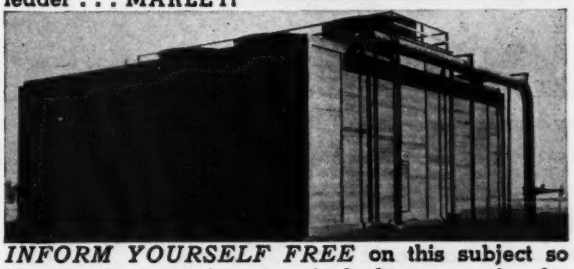

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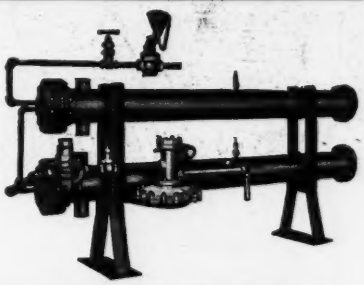

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The delivery is uniform, like a piston moving continuously in one direction. The De Laval-IMO pump has no reciprocating parts, no timing gears and can be run at electric motor or turbine speeds.

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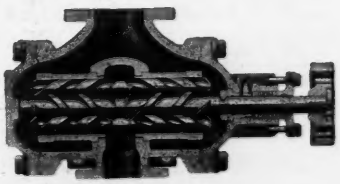

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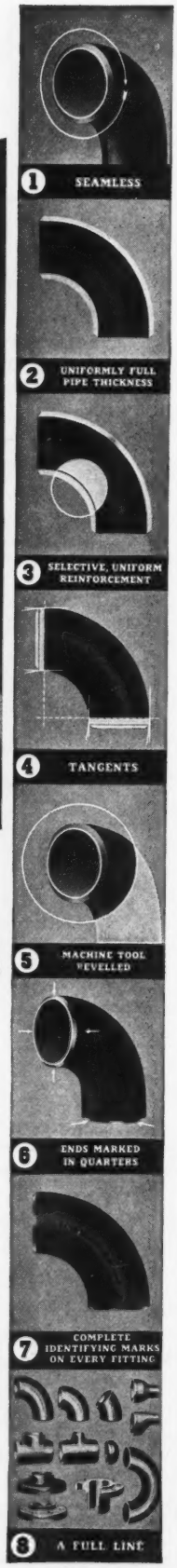
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De Laval Steam Turbine Co.
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Manzel Brothers Company

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Crane Co.
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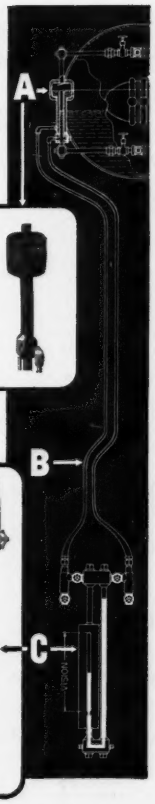

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Install EYE-HYE on each boiler to avoid dangerous accidents and costly plant shut-downs. Write today for Bulletin 382.

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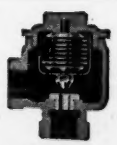
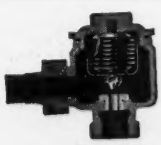

Type A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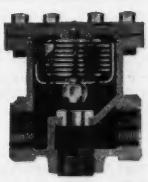
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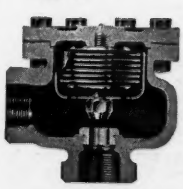
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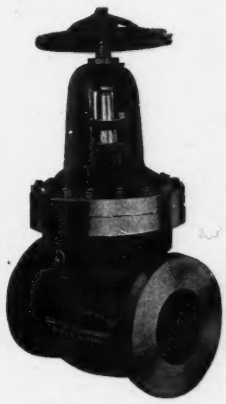
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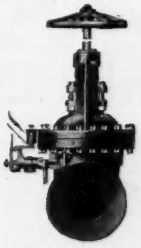
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Constant pressure control without wire-drawing effect assured with these specially designed steam reducing valves. Cushioning prevents pounding or chattering on varying steam flows. Available for high or low pressure service.

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Storage water control in tanks, standpipes or reservoirs is dependable with Altitude Control valves—the valves which for years established their invincible superiority. Air and water cushioning and no metal contacts accord a lifetime of efficient service.

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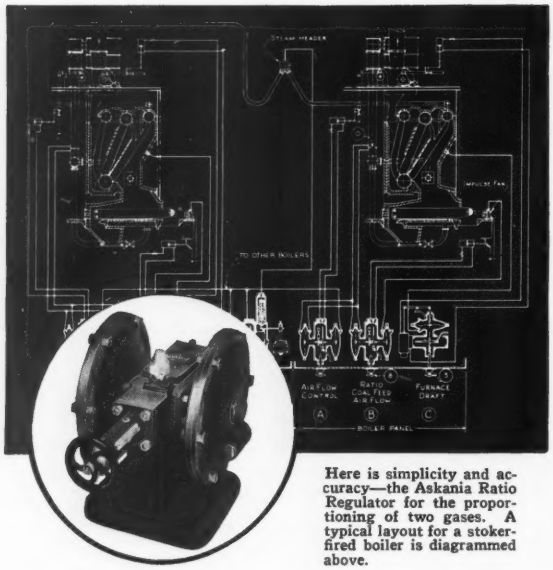

Here is simplicity and accuracy—the Askania Ratio Regulator for the proportioning of two gases. A typical layout for a stoker-fired boiler is diagrammed above.

What is it worth to be CERTAIN?

The obvious fact that indifferent regulation is worse than none, is bringing more and more attention to Askania control—control that not only is accurate, but stays accurate.

The heart of Askania Regulation is the jet pipe principle—a principle so simple, so versatile, that it *must work right*. The most elaborate Askania System of Control is simply a repetition or unification of these inherently trouble-free and almost incredibly accurate jet-pipe units. As a result, an Askania System as elaborate as that diagrammed above is just as dependable as a single unit controlling furnace pressure.

Ask for a complete description of this versatile system—and then ask yourself, "what other system of control offers so much?"

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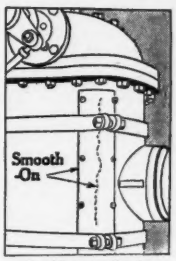
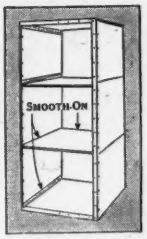
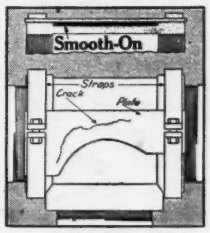


Patching cracks in pressure parts

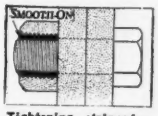


Stopping tank leaks



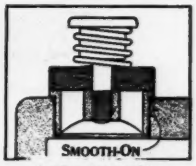
Patching cracked fittings

Sealing punctures

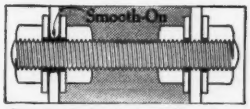


Tightening stripped threads

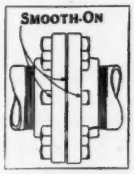
Sealing porous spots



Setting loose valves

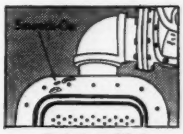


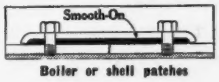
Stopping leaks at stay bolts and rivets



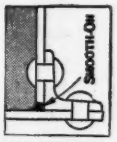
Repairing blow-out without disassembling

Stopping smoke leaks


Restoring pitted flanges



Boiler or shell patches

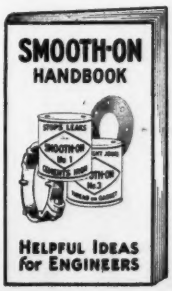


Stopping seam leaks

Dozens more explained in the Smooth-On Handbook

The instructions, working diagrams and helpful advice in this booklet are a reliable guide in picking out the right Smooth-On composition and application method to do *well* any repair job that you are apt to encounter —and by using Smooth-On you will save time, avoid much hard work, and get defective or damaged parts back into service at very low cost.

Judicious use of Smooth-On will reduce annual maintenance expense if you have this Smooth-On Repair Handbook handy and take advantage of its good suggestions.



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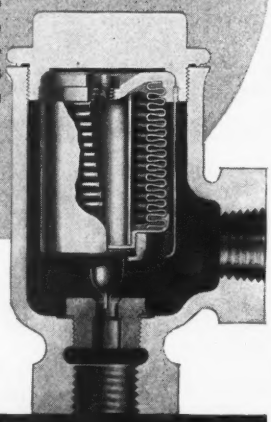

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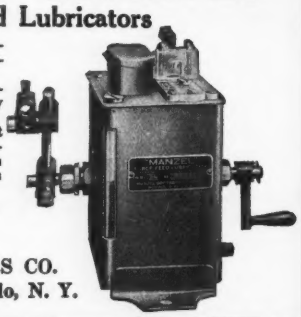

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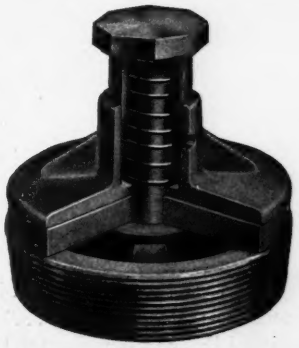

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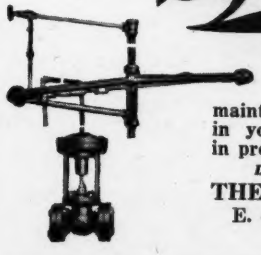

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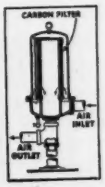

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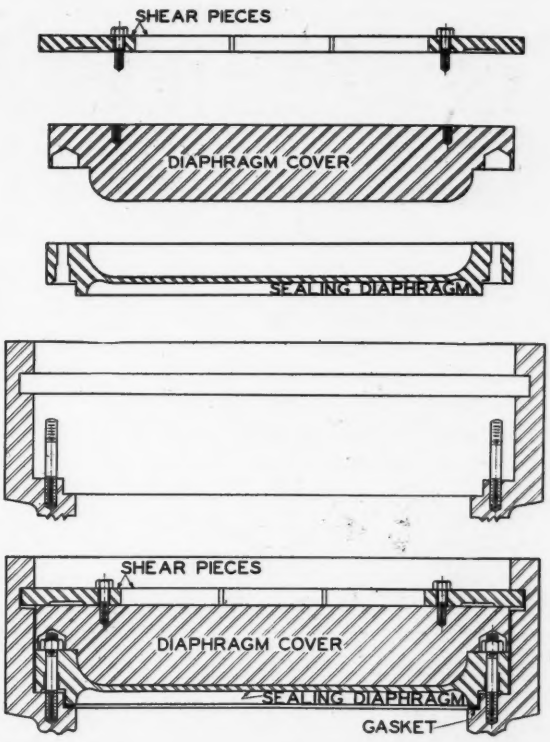

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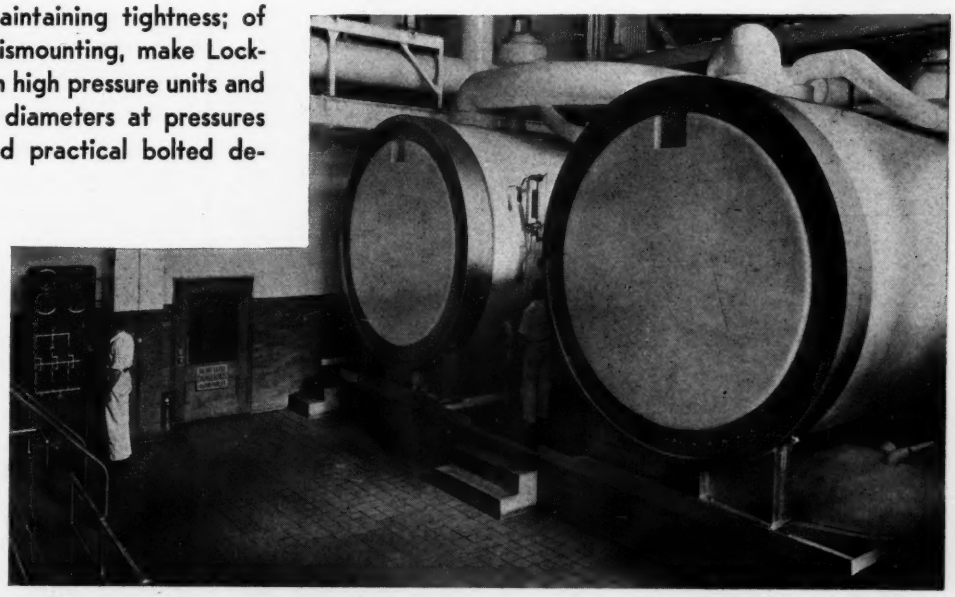

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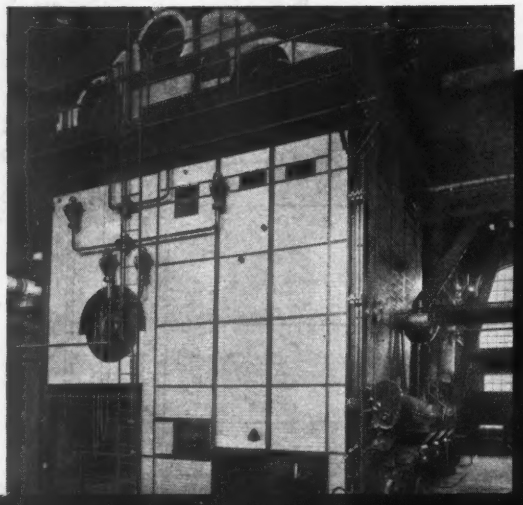

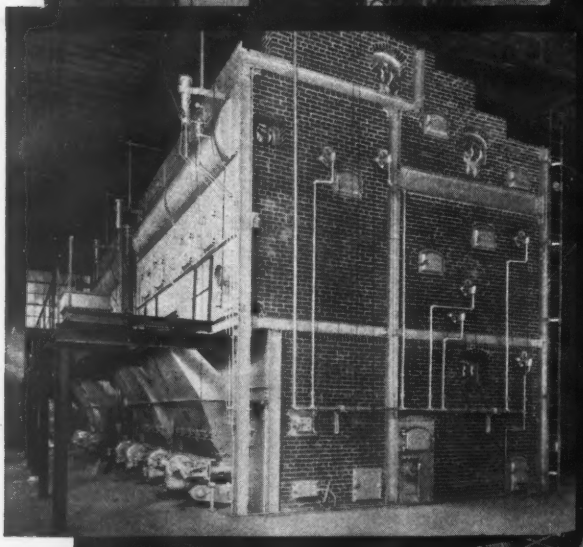

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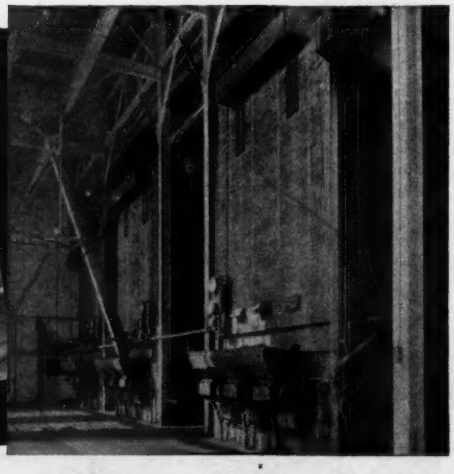

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